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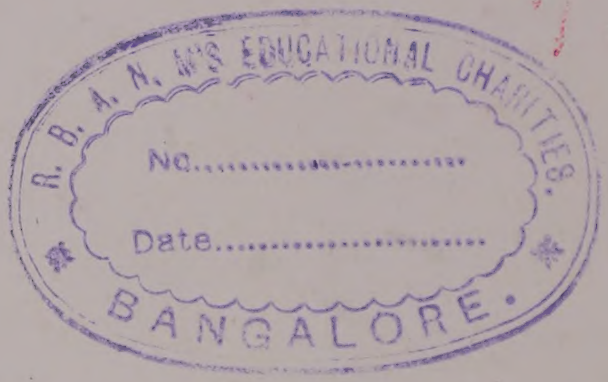

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ETON NATURE-STUDY

AND

OBSERVATIONAL LESSONS

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From a photograph specially taken by Messrs Lascelles & Co.

A Wild Cat and her Kittens.

In the possession of Mr Alfred Heneage Cocks, M.A., F.Z.S.

ETON NATURE-STUDY

AND

OBSERVATIONAL LESSONS

BY

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WITH A FOREWORD BY

THE REV. EDMOND WARRE, D.D., M.V.O.

Headmaster of Eton

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PART I

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FOREWORD

It is with great pleasure that I venture to commend this little work both to Teachers and Learners. I believe that it is sound in its method, and that it will not only help to train the minds of those who use it intelligently, but also lead the way to that further study of nature upon right principles which, as time goes on, affords for so many, a solace and delight amid the "sick hurry" and pressure of modern life. Any business man who takes a pleasure in his herbaceous garden, or in shrubs and trees, or in his farm, will know what this means.

Of all kinds of study, the study of nature pre-eminently deserves the encomium of Horace, "Omne tulit punctum qui miscuit utile dulci."

EDMOND WARRE.

Eton, *September* 1903.

AUTHORS' PREFACE

The value and the importance of nature-study are now so widely recognised that there is no need for us to dwell upon its interesting history. At the same time, however, seeing that in the teaching implied, we have to deal with a *method* and not with a subject, it will be well to make the standpoint, as regards general education, perfectly clear. In the first place it is now perhaps hardly necessary to say that in this sense "nature-study" is not synonymous with the "study of nature" or with "science," much less with any particular branch of the latter. True it is that the materials for nature-study are the sun and earth, plants and animals, even the weather, but these may be taken almost at random, and the informality of the pursuit is a pillar of its strength.

Hence it follows that the teacher need be no specialist nor qualified expert; all that is required of him is that he shall have broken away from the old didactic methods of imparting information, and have the enthusiasm which arises from a love of nature. On the other hand it is only fair to admit that in the hands of a trained biologist, the work must greatly gain, provided that his methods of teaching are such as will attain the ends in view.

Nature-study rightly interpreted should provide for the personal acquisition of knowledge and experience, during the early years of life, in a way that is interesting and above all *natural*. It should differ from the ordinary school task and savour in no way of the "information lesson."

The results of such teaching should be the capacity in after life of adding to the mental equipment already obtained, and of judging how to act under various conditions which must from time to time arise.

There is another side of the question. The average boy, at least, passes through a stage when the keeping of pet animals, the collecting of butterflies or the cultivating of a garden are sources of great delight. After a year or two of school life, however, he often "grows out" of these early interests, and it is as a rule not until far later in his life, if at all, that the aesthetic pleasures to be gained from an appreciation of nature, begin to make themselves felt.

In nature-study, however, the emotional senses are cultivated incidentally with those powers of observation upon which the work of the poet and artist depends, no less than the success of the man of business, the farmer, and the scientific investigator.

Furthermore, it must not be forgotten that nature-study adds greatly to the pleasure of life, rendering intelligible what is going on in forest and stream, in hedgerow and in garden, that it is part and parcel of all true sport, and paves the way to any number of fascinating hobbies.

There is a suspicion in the minds of some science teachers, to whom nature-study is as yet only a name, that its promoters wish it to take the place of science in secondary schools. Not only do we believe that this is entirely unfounded, but we hold most strongly that while all children should take part in nature-study, such work will be greatly strengthened if it be followed by definite courses of scientific training. On the other hand, as practical teachers, we have found that nature-study is the best possible preparation for the mind towards grasping the essentials of scientific method.

In the case of elementary schools, however, it is questionable whether the scholars, as a rule, stay there long enough to be able to do any scientific work. It is not surprising, therefore, that the importance of introducing nature-study into these schools, and of encouraging informal out-door lessons, was officially recognised by the Board of Education some years ago.

The advantages, also, of co-relating such work with ordinary subjects of the curriculum, such as drawing, essay writing, and geography, have been largely seized by teachers of all grades who understand that nature-study may be to a great extent "a point of view."

At present the private and elementary schools have led the way, and there is no doubt but that where the number of pupils is not very large, special facilities exist for informal out-of-door work during school hours; while in the large secondary schools, the nature-study, if any is done, is to be looked for, in the observational side of that voluntary natural history work which is generally treated as a mere pastime, and only here and there taken at its full value.

It is advisable that some ideas as to the direction to be followed in nature-study should first of all be obtained in school (under existing conditions at least), and that the fullest advantage should be taken of voluntary work which will receive encouragement thereby.

The object, therefore, of this book is twofold. First of all to provide a series of truly observational lessons which may be carried on as a part of a school curriculum as set down in the time table, or, where possible, incidentally introduced.* Secondly, by means of a number of chapters, to suggest as many lines, as is possible, of work to be done out-of-doors in school time or in leisure hours.

In the case of students who have begun their scientific training it will be difficult to determine where nature-study ends or science begins; and there is no need to attempt to do so, as the out-door observational work will always supplement that of the laboratory. In simple nature-study, books of information are not used, but when a special pursuit is seriously followed as a hobby, it will be necessary

* The subjects chosen provide so far as possible for a continued study and are seasonal but not necessarily connected one with another.

to use the experience of others. Hence, references have been given to recognised works, in the various chapters.

Finally, it may be pointed out that the chapters contain but few facts for the amusement or benefit of the amateur naturalist, and we would say that throughout the book we have invariably striven to avoid giving more of such information than is absolutely needful. There are, at the present time, many excellent books which deal with the bionomics of animals and plants, and enjoy a deserved popularity. Nevertheless we are convinced that knowledge derived first hand from nature herself will in the end produce infinitely greater satisfaction than anything that can be gathered from books, however charmingly presented to us. We have, therefore, done little more than to suggest lines of investigation which, we hope, may not only be found useful themselves as part of nature-study, but if conscientiously carried further prove also to be of permanent scientific value.

Our thanks are due to the Rev. Dr Warre, Headmaster of Eton, for the kindly encouragement which he has given to our work; and to Mr Alfred Heneage Cocks, M.A., F.Z.S., for the opportunity afforded to us of photographing his unique collection of British Carnivora, and the time and trouble which he spent in our interests. We are also indebted to Miss F. Davenport-Hill for her ready help: to Captain H. B. Hill, R.A., and Mr Charles Sillem for many suggestions, and for reading our proofs, as well as to those whose assistance is acknowledged in the text. Our gratitude is lastly due to Mr W. J. Webb for the care and skill which he has bestowed upon the original drawings which illustrate the book: to Mr A. A. Neave (of Messrs Lascelles & Company) for the ingenuity and perseverance to which we owe our pictures of wild cats; and to Mr F. W. Reader for the trouble taken with the blocks.

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INTRODUCTION

THE MAKING AND RECORDING OF OBSERVATIONS—ILLUSTRATIONS—PHOTOGRAPHY—THE USE AND MISUSE OF COLLECTIONS

In the practical pursuit of nature-study, it is possible to rely entirely upon the memory with regard to the many facts discovered. No doubt much good may in such case be forthcoming, especially where very young children are concerned; but it is advisable that the student should, as soon as possible, learn to note down clearly and in concise language what he sees. In continued observation, moreover, some kind of record is almost a necessity, if comparisons are to be accurately made, interest maintained, and the pleasing character of the work made clear to others. The whole movement in favour of nature-study may suffer also, if there is "nothing to show" for all the energy expended, by comparison with activity in less valuable branches of education, of which the immediate results are more obvious.

Written accounts first suggest themselves. These may be made much shorter and at the same time more useful than they otherwise would be, by the addition of illustrations. The roughest diagrams may often be as great an aid to memory as the most artistic and elaborate drawings, which it will be beyond the power of many to produce. Sometimes, again, a photograph—and there are few who cannot learn to use a camera—may be the best means of recording an observation. Models, though more bulky, may replace other illustrations; and lastly, an actual specimen or series

of specimens may be of the greatest service. It is true that the help which the copying of form or shape gives to the memory will be lost in the case of photographs and real objects, but the

A PLUM.

(1) Size:– . 45 × 33 millimetres.
Shape:– egg-shaped
Colour:– red, lighter on one side
Observations on the external appearance:–
The skin is covered with a bloom; smooth. There is a groove down one side. The stalk is green, and fits into a little pit.

(2) Thickness of Skin:– ½ millimetre
Colour beneath Skin:– greenish-yellow
Consistence of Flesh:– soft and juicy.
Remarks:– The skin peels off very easily, and in the flesh are numerous little fibres. The skin on the lighter side does not come off so easily.

FIGURE 1.—A SPECIMEN LEFT-HAND PAGE OF THE NOTE-BOOK, on which Headings and Notes have been written.

preparation of these counts for something, and details that escape attention at the time, are ready for reference in case of doubt at any future date.

A few strokes of the pencil will serve to indicate the size of a seedling at different times, or the position of a tendril at certain hours of the day, but in order to bring home the beauty of a flower which has

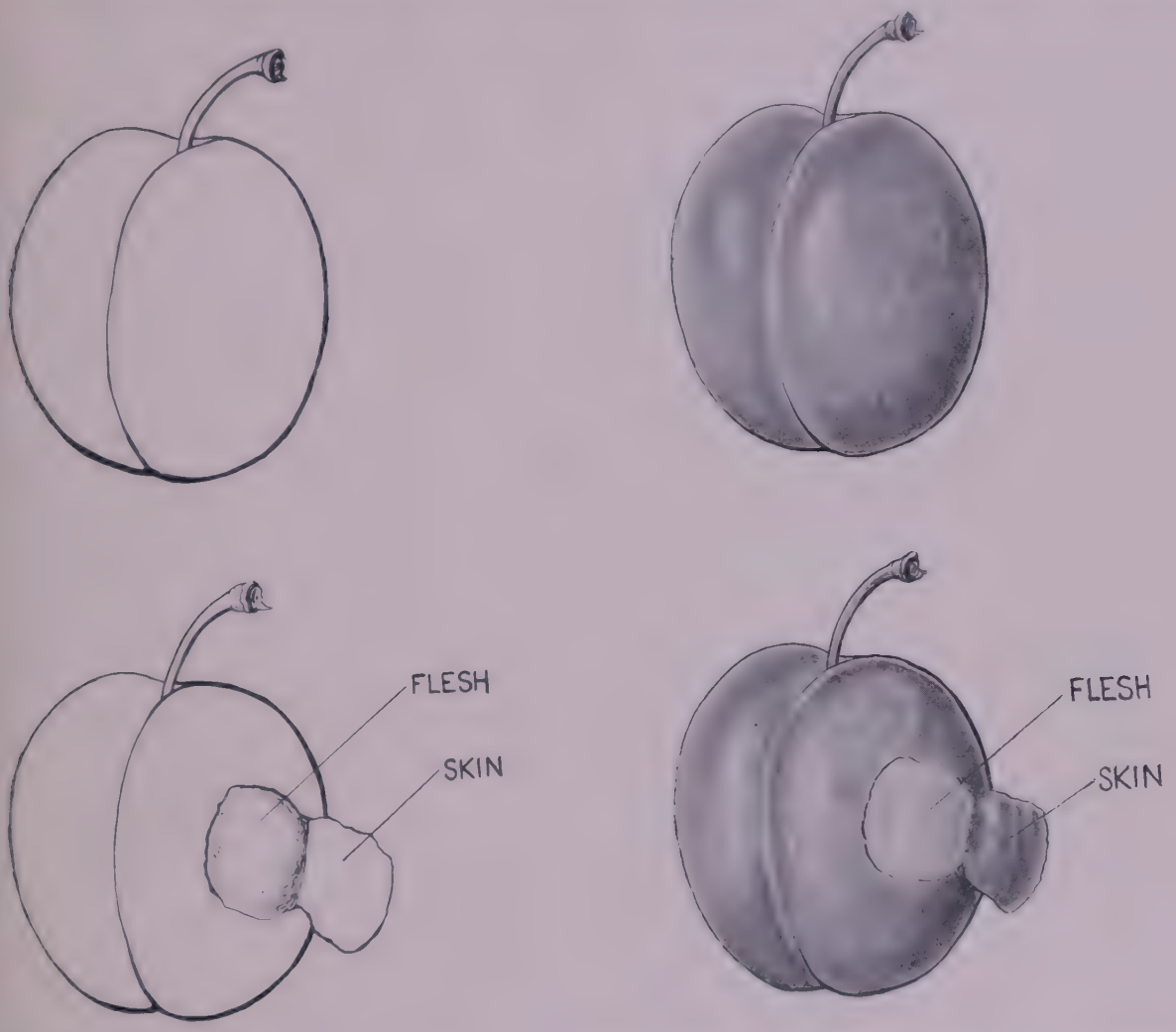


FIGURE 2.—A SPECIMEN RIGHT-HAND PAGE OF THE NOTE-BOOK, on which Outline Diagrams and Water-colour Sketches have been made (see directions on page 4).

been found for the first time, a finished picture in colour may be necessary. In cases where time is short, and it is not possible or

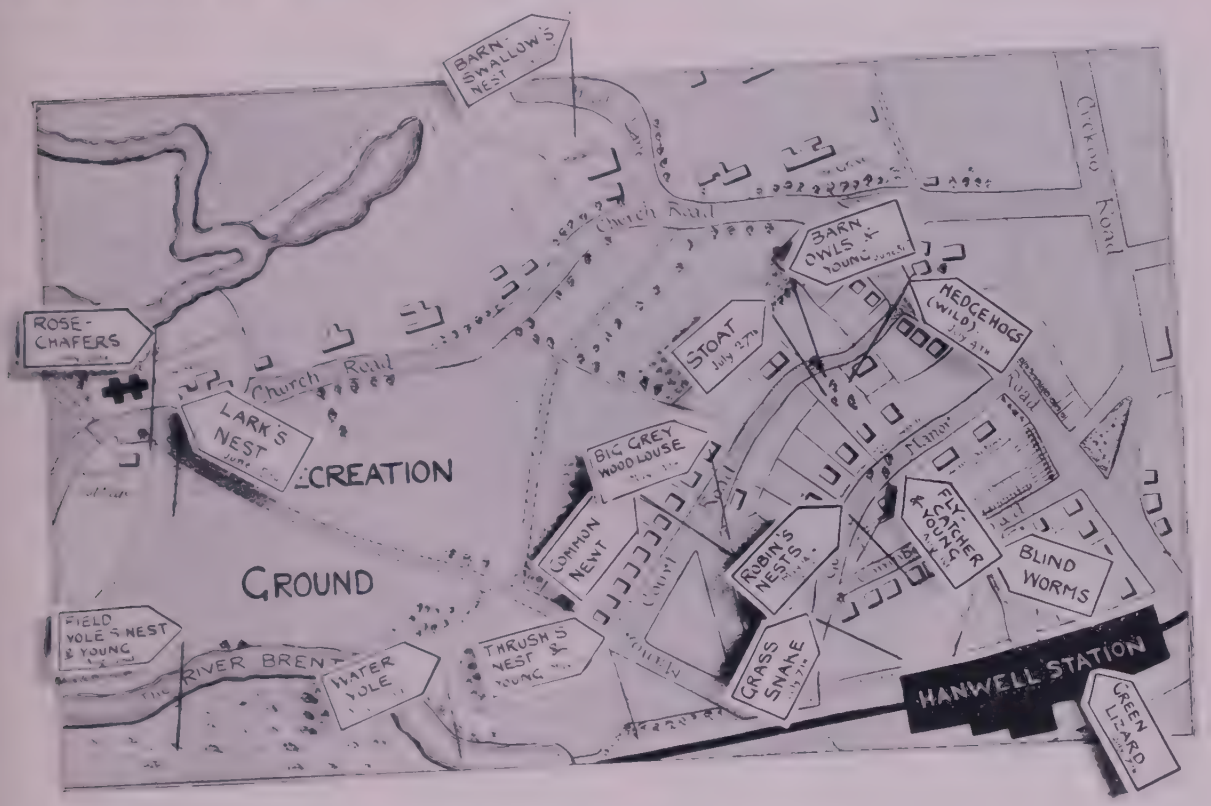
desirable to remove the object of study, such as the surroundings of a bird's nest or the edifice itself—photography is of the utmost value. Those who do not wish to sacrifice an interesting caterpillar when illustrating its life history, may get over the difficulty by making a model which will often look even better than the inflated skin of the real animal. In studying the foliage of trees with a view to the recognition of the commoner kinds, no drawing could be so useful for reference as a set of the various leaves already found.

Notes, of which the interest or usefulness depends upon their chronological order, may be made in ordinary books, the writing being put on the left hand page, and the pictures on the right. (See figures 1 and 2.) Long experience, however, goes to show that details with regard to any special study to which additions are continually being made, are best entered upon papers which permit of an easy re-arrangement, and which differ in character according as they are used for drawing or for writing. As a rule, such sheets would have to be kept loose in a folio, box or large envelope, which is not convenient when they have to be carried about. A note-book of a special character has, therefore, been designed, to which fresh leaves can be added, and from which they may be transferred to another of the same kind. (See Appendix, page 148.)

It is perhaps necessary to emphasize the fact that whatever may be the case in scientific work where the investigations of others have to be taken into consideration, in nature-study, all notes and illustrations must be the work of the individual. For the same reason, extracts from the poets, though valuable in connection with nature-study as serving to keep its emotional side to the fore, should rather be written out in a separate book with a note as to the observations which recalled each passage.

The use of collections will be touched upon in Part II, but it is

not suggested that children in their nature-study should make those accumulations which are generally recognised under the name. Such specimens as the set of leaves already indicated, series of twining plants, and stages in the growth of insects which have been reared, are those which are useful and to be encouraged. A rough investigation



* FIGURE 3.—A Map showing the method of recording observations by the use of flag labels.

into the animals and plants which inhabit some particular and definite area, may call for any or all the methods of recording we have alluded to. Instead of keeping specimens, however, after they have been once recognised, they may be allowed to go free, and

* This idea was first illustrated at the Nature-Study Exhibition, 1902, by Miss Ethel Webb, of Streatham High School.

their names entered upon a specially prepared map or plan. It may be useful for observations which have been recorded to be prominently before the eye for a week, or may be for a season. This can very well be done by means of a map and flag labels, the staves of which are large needles. (See figure 3.)

In detailed local work and the *scientific study* of some special branch, it is necessary to have specimens, or a working collection, as it is called, but the indiscriminate killing and hoarding of creatures, or the taking of scarce specimens just because they are rare, is to be avoided and condemned.

Note:—In the lessons which follow the preparations to be made beforehand are first indicated and directions for the pupil are then given.

The work is so arranged that each pupil in a class shall observe individually. Little direct information should be imparted by the teacher, who must supplement the directions by judicious questioning.

So far as possible the various points should be noted one by one, each under its own heading. This and the introduction of drawings permits of the observations being easily checked, while the use of a large note-book (say 11 in. by 8 in., see Appendix, page 148) allows for the addition of corrections.

Suggestions are made here and there for work out of school, in addition to the chapters, which have been specially written with a view to its encouragement.

Some idea is also given as to how a lesson may be continued or supplemented, but in many cases the work of doing this, has been left to the teacher.

The lessons are planned so as to occupy about an hour; but it is quite possible and advisable in many cases to bring in the observations given under a single number, as a relief from ordinary school work—unexpectedly or at a prearranged time.

OBSERVATIONAL LESSON I

Part I—A Plum

Preparations for Work

Each pupil must be supplied with two plums. Both specimens should, if possible, have stalks, and one, at least, should be fully ripe.

Directions to the Pupil

(1) Write down in ink on the left hand page of your note-book (near the margin and one beneath the other) the headings given below in the left hand column. Fill in details in pencil from your own personal examination of the specimens. On the opposite page make and label the diagrams suggested, leaving a space on the right hand of each for a water colour drawing. (See figures 1 and 2 on pages 2 and 3.)

Figure 4. — A Plum cut through, and showing the seed laid bare by the removal of part of the stone.

RIPE SPECIMEN

Left-hand page of the note-book	*Right-hand page of the note-book*	
Describe :—	Make :—	Leave :—
Size Shape Colour	An outline diagram of the fruit and stalk	A space for a water colour sketch to be made at your leisure
Record :—		
Observations as to external appearance		

(2) Push your nail through a portion of the skin, and peel a piece partially off, taking care not to detach it entirely from the fruit.

Note :—	Draw :—	Leave :—
Thickness of the skin Colour beneath the skin Consistence of the flesh Other characters	A diagram showing skin and flesh	A space for a water-colour sketch

(3) With a sharp knife cut down to the depth of the stone, starting from the base of the stalk, and passing round the top of the fruit to the stalk again. Remove one half of the flesh and skin.

Give :—	Make :—	Leave :—
A description of the flesh Size of the stone Colour of the stone Consistence of the stone Other characters	A diagram of a section of the fruit	A space for a water-colour sketch

(4) Open the stone with a file and pliers, or examine one which has been so opened.

Write down :—	Make :—	Leave :—
The number of kernels or seeds The size of the seed The colour of the seed	A diagram of the seed as it lies in the stone	A space for a water-colour sketch

(5) Take out the seed and remove its coverings, also cut another seed across.

Give :—	Make diagrams of :—	Leave :—
The number of coverings Description of these	(*a*) The seed (*b*) The seed cut across	Spaces for water colour sketches
The colour of the tiny plant, with the number of its leaves	(*c*) The tiny plant	
A list of other parts which can be made out	(*d*) The latter with one leaf removed	

Suggestions for further Work out of School

Sow some stones either in pots or in your garden

Give an account of :—	Leave spaces for :—
The unfolding of the leaves The time of flowering of the plum (to be filled in during next year) The ripening of the plums	(*a*) A water-colour drawing of flowers on a branch; (*b*) for a sketch of ripe plums on the tree

The notes may be further elaborated by the addition of photographs of the tree, or in other ways.

Suggestions for further Work in School

Compare a grape and an orange with a plum.

Part II—A Seed Pod

Preparations for Work

Every student or, if this is not possible, each pair of students, should have a dwarf bean plant bearing flowers and fruits, and growing in a pot.

Directions to the Pupil

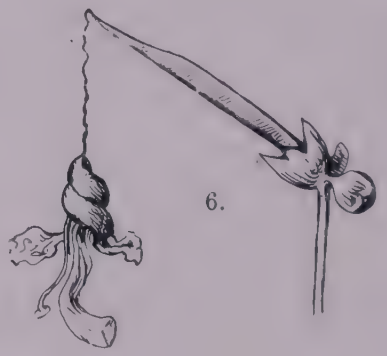
(6) Choose a bean pod which has just pushed off the dried-up petals of the flower. (See figure 5.)

Record :—
- Size
- Shape
- Colour
- Other observations

Make :—
An outline diagram drawn to scale, two or three times the natural size

Leave :—
A space for a water-colour sketch

5.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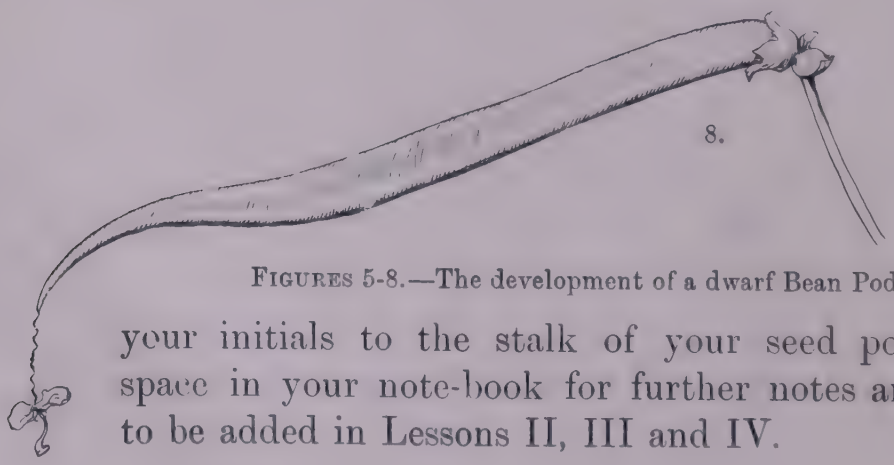
8.

Figures 5-8.—The development of a dwarf Bean Pod.

Date your drawings. With a piece of cotton, tie a small label bearing your initials to the stalk of your seed pod. Leave space in your note-book for further notes and sketches to be added in Lessons II, III and IV.

CHAPTER I

Out-Door Studies in Autumn

THE DISPERSAL OF SEEDS—THE MIGRATION OF BIRDS

The Dispersal of Seeds

For those who are fond of plant life, few more charming studies for the fall of the year could be suggested than the subject of fruits. That is to say, if they are first of all considered in their relationship to the welfare of the seeds which they contain. It is easy to see that two points of the highest importance are the carrying away of the offspring from their immediate birthplace, where they might suffer from competition with the parent plants, and the scattering of the new individuals so that they do not interfere one with another.

FIGURE 9.—The fruit of Caper Spurge.

FIGURE 10.—The ripened fruit of Caper Spurge bursting and scattering its seeds.

The observations which can be made, though they may begin with the discovery of contrivances to ensure seed dispersal, need not end with an assumption or even an enquiry from books as to their meaning. Actual instances of their uses should be watched for and described in a nature note-book which may be set apart for the purpose. The most common and well known cases (see figures 11, 12) will serve as subjects for study, but there is no reason why others should not be sought for and found. It may be possible to add important details about many fruits to those which naturalists already know about them.

FIGURE 11.—The fruits of Robin-run-in-the-hedge.

For instance, the hooked heads of the burdock (see figure 12) are a good instance of structures which are intended to stick to the bodies of animals and so be conveyed to distant places. It might be imagined that the removal of the fruits from their carrier is left to chance, or that the whole head might in time drop off and the dispersal of its contents be carried no further. Before long, however, the fine bristle with which the top of each tiny fruit is beset, work their way through the hair of the animal, or the stocking of the human being to which they have clung, and tickle him. Scratching or rubbing will break up the bur still further, and one or more of the fruits (each of which it can be discovered contain a single seed) drop to the ground on each occasion.

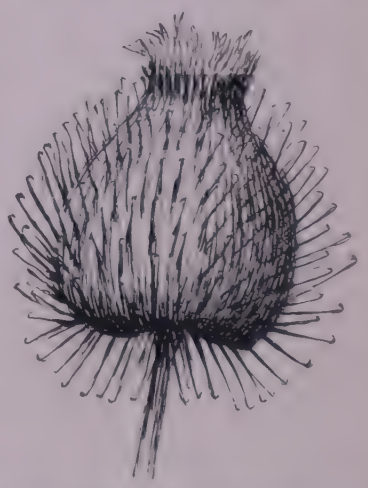

FIGURE 12.—The head of Burdock.

Drawings will serve to render the records of observations clearer, and some attempt should be made (see page 4) to keep together notes on plants which scatter their seeds in the same general way.

An additional interest attaches to those cases in which animals are forced, (see figures 11, 12, and 13) or tempted into helping the plants to

FIGURE 13.—Fruit of Barley Grass.

FIGURE 14.—Fruit of Goat's Beard.

FIGURE 15.—Fruit of "Old Man's Beard."

scatter their seeds. In the latter class come seeds that are provided with edible portions which surround or support them, and in the winter time, when birds have little else to eat, it would be useful to notice any which feed upon hips or haws or particular kinds of berries.

Other instances where the aid of wind (see figures 14 and 15) or water is reckoned upon and where automatic movements (see figures 9, 10 and 16) on the part of the fruits or seeds are arranged for, will also come to mind.

A series of specimens may very easily be kept, and although it

will take up more space than many pressed flowers, it can be made a great deal more useful and interesting for the purposes of nature-study. Fruits which are not juicy, dry very well and may be mounted without any special preparation. If it is sought to prevent as far as possible the distortion which must to some extent take place, the specimens may be buried in specially dried sand as described in Part II in the chapter on "The proper study of flowering plants." The fruits, in order to be most of service, should be mounted, and it need not be said that nearly the whole value of the series lies in the labels which are attached to the specimens. The latter should be chosen, therefore, so as to show all the details possible. Parts of fruits and individual seeds should be made use of, when necessary, in order to make the story complete.

FIGURE 16.—The fruit of Crane's-bill.

FIGURE 17.—A glass-topped box containing fruits of Willow Herb.

If the series is to be displayed, the individual examples should each be mounted in glass-topped boxes, made for the purpose (which can be bought for a few pence apiece). (See figure 17 and page 149.) Otherwise, still cheaper boxes may be used, or trays and lids made

from any suitable cardboard at hand. Juicy fruits will have to be kept in fluid. (See page 149.)

The Migration of Birds.

It is always interesting to watch the migrations of birds —the appearance of new comers on the approach of winter and the departure of the summer visitors which have nested with us. A "bird calendar," as shown below, though intentionally somewhat meagre in itself, may form a basis for many detailed notes and records.

The entries for a week, say, in the first year of observation, may be written upon a single page, and those for a corresponding period in the next and following seasons can be inserted into the note-book (see page 4) so as to be readily available for comparison. If a complete calendar in the style of the one given has been carefully kept, much accurate information will have been gained as to the appearance and departure of our regular migrants. That is to say, of those kinds of

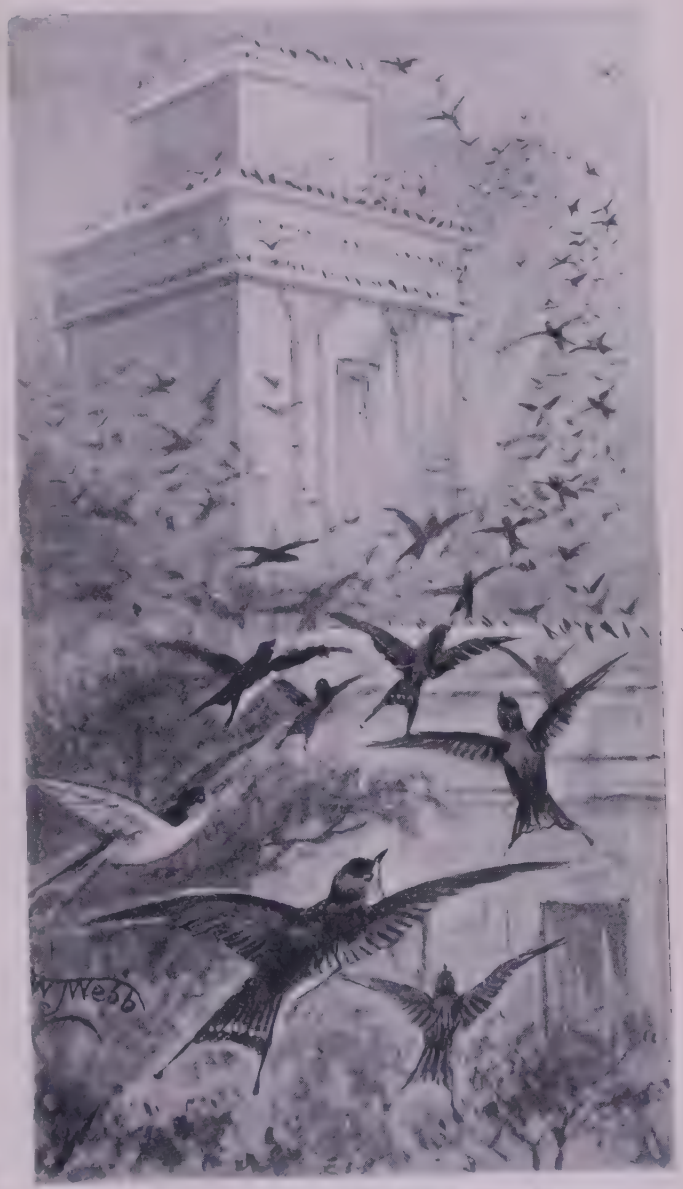

Figure 18.—Swallows collecting round a tower, near Redhill, before migrating.

A Bird Calendar.*

* From notes made at Rosehill, Cheadle, Staffordshire. By John R. B. Masefield, M.A.

1903. 6th July.	Five young Sparrow Hawks in a nest in a larch tree are almost ready to fly. They crouch down close to the nest when anyone approaches and cannot be seen from below. The parent birds appear to keep away from the nest during the day, feeding the young only early and late. The pellets ejected by the parent birds show skins and bones of field mice, voles and shrews, with wing-cases of beetles.
7th July.	A brood of young Pied Wagtails leave the nest, which was built in the ivy against the house. The first nest was built a few feet higher up, but the eggs were sucked by house sparrows.
8th July.	I found a young Cuckoo which had only recently left the nest, lying dead on a garden path. It had apparently been killed by striking some object in its flight, as the front of its head was crushed in. This bird having been hatched in my grounds makes the fortieth wild species that has bred with me during the last few years.
9th July.	I counted five pairs of Spotted Flycatchers' nests on little wooden brackets placed in the corners of windows and other sheltered places on the house.
10th July.	I saw a flock of Peewits standing in a meadow in their usual triangular form with heads facing the wind. Starlings, which appear to be increasing in numbers every year, congregate in the evening, roosting in mountain ash trees.
11th July.	The families of Blue and Cole Tits which were bred in nesting boxes and holes in walls are now doing good service in clearing trees and crops of the destructive larvae of moths. Hawfinches have found out the green peas and are being trapped by irate gardeners. A small flock of gulls passed over to-day, going westward.

12th July.	I suddenly came across a Landrail and her brood of young, covered with black down, on a garden path. She at once feigned injury and tumbled about as if unable to fly. Meantime the young birds ran through a fence into long grass, while the mother tried to attract my attention. Once or twice she went to see if the little ones were in a place of safety, but only when they had gone many yards away, did she finally leave me and follow them.
14th July.	Swallows have laid eggs again and within a few days of the first brood leaving the nest. The young of these birds appear to be able to feed and take care of themselves very soon after they fly; the young of many other birds, such as the Robin, the Spotted Fly-catcher and the House Sparrow being fed by their parents for some time after leaving the nest.
15th July.	Returning home at dusk I heard several Nightjars "churring," and by approaching carefully, came upon a bird perched on the extreme top of a Scotch Pine. The song of this bird, when one is close to it, is far more musical than at a distance, and seems to consist of two or three notes, and is uttered when the bird is perching, and with the head on a level with, or lower than the body.
16th July.	I observed a Yellow Hammer singing his drowsy song, perched on the top of a Hawthorn Hedge by the wayside.
17th July.	I found a Greenfinch's nest built in ivy against a stable wall about ten feet from the ground. This is an unusual place for the nest of this bird, which generally builds in hedges or low bushes.
18th July.	Turtle Doves feeding on weedy arable land, where they consume the seeds of many noxious weeds, such as knot grass, orache, etc., and thus render good service to the farmer. Willow Wrens and Chiff Chaffs resume their songs, having completed their family duties.

birds of which all the individuals disappear at one time of the year or another.

The practice in observation will be considerable, and the interest to the student equally great. The knowledge acquired, however, will probably not include any facts hitherto unknown, and if the pursuit is in the end adopted as a hobby, something in the way of original investigation will be sought for. This can be found in another branch of the subject, to wit :—that which deals with species of birds of which only the majority of the members vanish, a few being always present. In this direction there is much still to be discovered.

Such partial migrants as the pied wagtail, the songthrush, and the red-breast would certainly repay the closest watching. We are still ignorant of many of the causes which determine the presence of these birds in varying numbers in particular spots during different seasons of the year. Careful observations made in different parts of the country, as to the relative number of partial migrants in each month, and a co-related table of the conditions as to climate, food supply, presence or absence of special enemies, would therefore be of the greatest use. To do this would certainly be a more difficult task than the making of such a calendar as has been given above ; yet a few notes taken daily by the nature student on the lines suggested, would, at the end of a series of years, furnish valuable data for the agriculturalist, the bird protector, and the expert naturalist to work upon.

When we see how dependent all forms of life are upon one another, and how keen is the struggle for existence among individuals of the same and allied species, it is obvious that the causes which led to the present forms of living things must be looked for in the relations of animals and plants to their surroundings.

It is a fact generally becoming recognised, that for the solution of many of Nature's most difficult problems, we must look to the

FIGURE 19.—Barn Swallows returning in pairs and landing on the Isle of Wight.

labours of the field-naturalist rather than to work which is confined to the laboratory or museum.

OBSERVATIONAL LESSON II

Part I—A Seed Pod (*continued, 2nd Investigation*)

Preparations for Work

The bean plants must be again distributed.

Directions to the Pupil

(1) Record :—	Make :—	Leave :—
The amount of growth made by the seed pod since your last observation	A diagram, drawn to the same scale as before	A space for a water-colour drawing

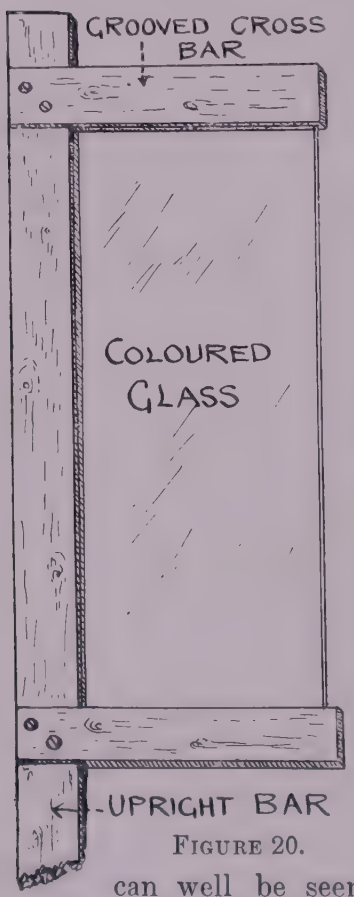

Figure 20.

Part II—The Sun*

Preparations for Work

Choose a window through which the sun when shining can be seen at noon. Procure a bar of wood (say 6 feet × 3 inches × $\frac{3}{4}$ inch) and a strip of coloured glass (say 10 inches × 4 inches) and two small pieces of wood provided with grooves in one edge into which the glass will fit. (See figures 20 and 21.)

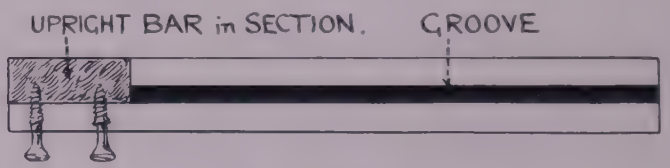

Figure 21.

Near the window find a place from which the sky can well be seen, and if necessary stand upon a stool. Make a mark

* This method of nature-study was introduced into Llangattock school by Mr D. Lewis some years ago.

upon the floor just in front of the chosen spot, and on this place the bar of wood upright. Slide the glass along the bar until it is before the eye, and having marked its position, fix the two smaller pieces of wood at right angles to the bar (see figure 20) so that they project and can be made to carry the glass strip.

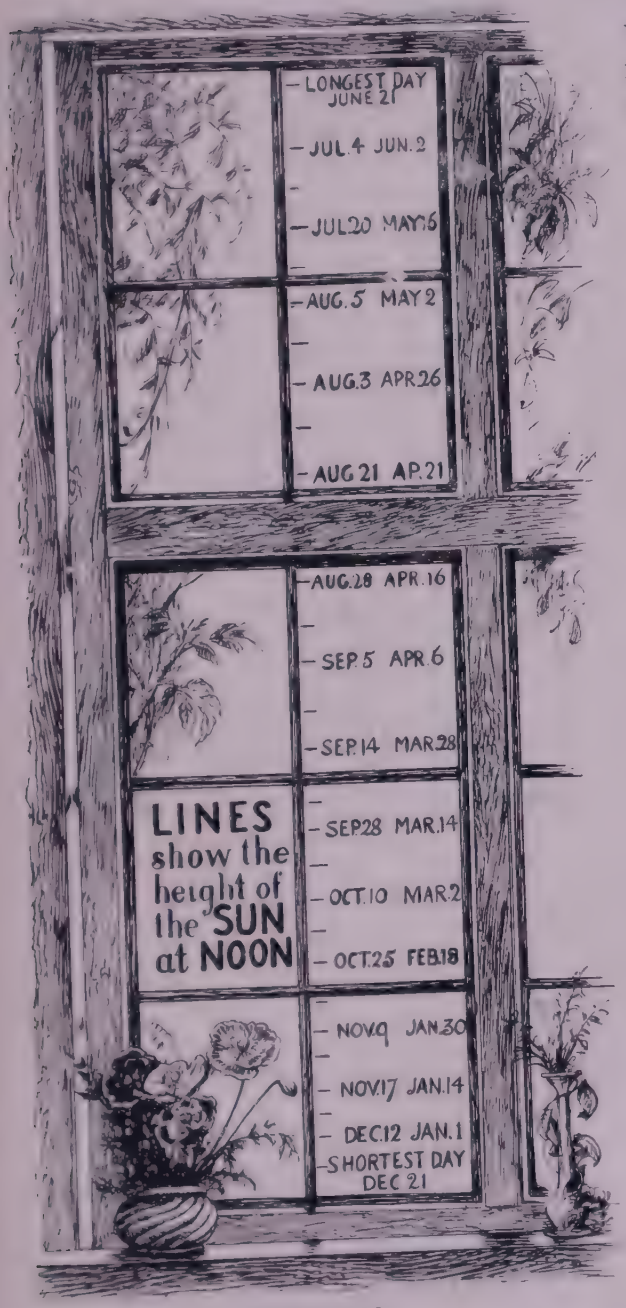

FIGURE 22.

DIRECTIONS TO THE PUPIL

(2) If the sun is not shining, the alternative subject given below is to be proceeded with (page 23).

Otherwise, at noon one observer must look through the glass at the sun, and a second should make a mark on the window pane at the place where the sun is seen to shine through it by the first student, according to his instructions.

The date must be added.

On a left hand page write a brief description of the way in which the mark was made on the window.

On a right hand page make as large a diagram as possible of the window. Mark the pane to correspond with the position of the sun and neatly add the date.

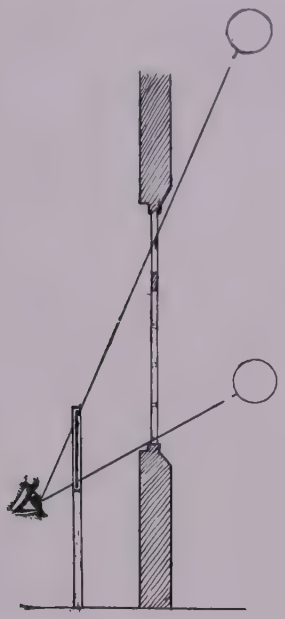

FIGURE 23.—A diagram to show the position of the sun on the longest and shortest days.

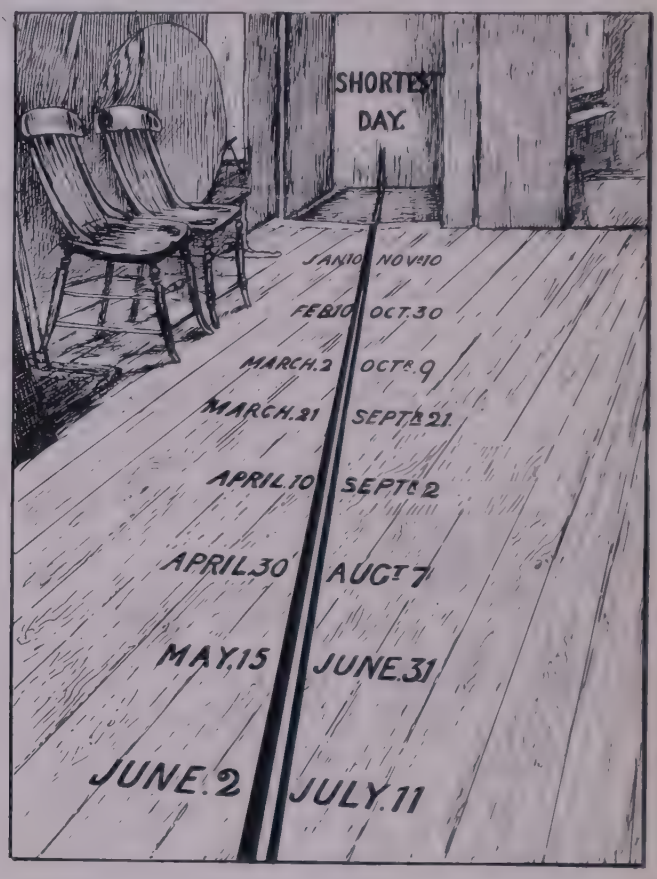

FIGURE 24.—Records of the position of a shadow on the floor.

(3) Select one of the bars of the window sash, and make on the floor a mark corresponding with the position of its shadow at noon, and put in the date. (See figure 24.)

Write a description as before and make a plan of the floor of the room on which to show the position of the shadow.

Note :—The shadow may be traced throughout the year in the same way as the apparent "position of the sun on the window."

Subsequent observations will show how the sun's position changes

and that one mark will usually represent its place on two days in different seasons. On June 21st—the longest day—and December 21st—the shortest day—when the height of the window is ample enough, there will be but a single record marking its highest and lowest positions respectively. (See figure 22.)

ALTERNATIVE SUBJECT

Seed Pod and Flower

Preparations for Work

Should the sun not be shining, additional observations may be made upon the dwarf bean plants already used in Part I.

Directions to the Pupil

(2a) Choose a fading flower from which the green seed pod is beginning to free itself. Compare it with three others in order to see the changes which take place.

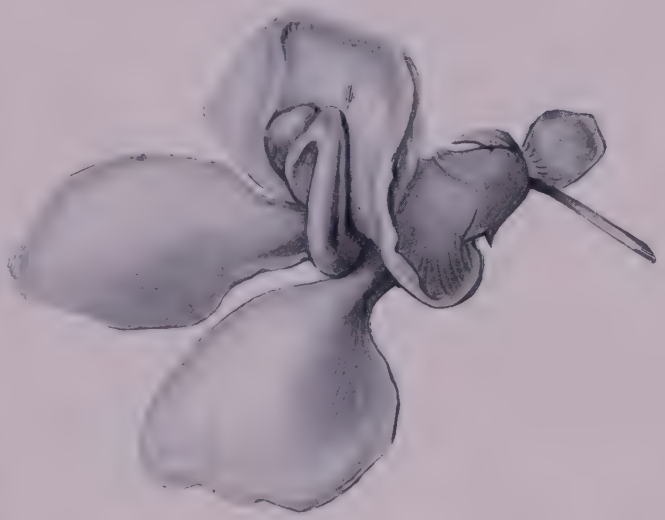

Figure 25.—The flower of a Dwarf Bean.

Make :—

Four series of notes as to the :—
- Size of the seed pod
- Position of the seed pod
- Behaviour of the petals

Make :—

Sketches of four chosen seed pods to show the changes which take place during growth

Leave :—

A space for four water-colour drawings

(3a) Examine a newly opened flower.

Record :—

The position of the seed pod

The reason why it cannot at first be seen

The appearance of any other structure besides the seed pod and petals

Make diagrams of :—

(*a*) The flower

(*b*) The seed pod laid bare

(*c*) Other structures seen

Leave :—

Spaces for water-colour sketches

FIGURE 26.—The flower of a Dwarf Bean from which the petals have been removed.

FIGURE 27.—The young Seed Pod of a Dwarf Bean.

CHAPTER II

THE MAKING OF A SUNDIAL—OBSERVATIONS UPON CLOUDS—NAKED EYE ASTRONOMY

The Making of a Sun-dial

Shadows cast by the sun under various conditions may be considered still further. Observations of the kind suggested have a bearing upon everyday matters and a connection with geography which should not be overlooked.

We would suggest the practical construction of a sun-dial as one piece of such work.* For this it is necessary to find a level surface, and to devise a means of supporting a small rod so that it can be moved at will. A log of wood stood on end (see figure 28) may provide the first, while an empty chip match box and a wooden skewer form convenient material in the second case.

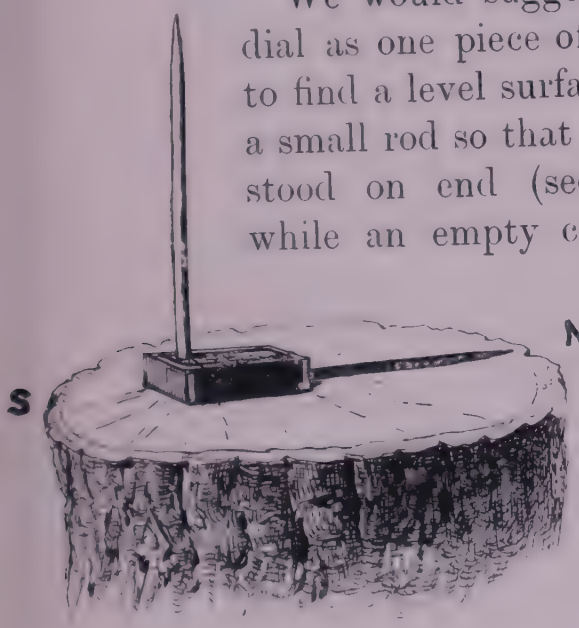

Figure 28.

Pierce a hole with the point of the skewer in the top of the box, near one end, and insert its broader end. If necessary the box may be filled with sand in order to make it more steady.

Put the arrangement where the sun will shine upon it and observe the length of the shadow thrown by your skewer at different times

* At Queenswood School, Clapham Park, where this observational work has been carried out for some years by Miss Nellie Sweeney, a retort stand is used to form the upright.

of the day. At noon the shadow will have shortened as much as possible, and just as it begins to lengthen again, mark its position and draw lines upon the log so that on subsequent days the match box can be replaced in exactly the same position.

Careful comparisons will show that the shadow of the upright skewer will not fall in exactly the same place at the same time of day, and some alteration is needed before a sun-dial, which is at all reliable, can be made.

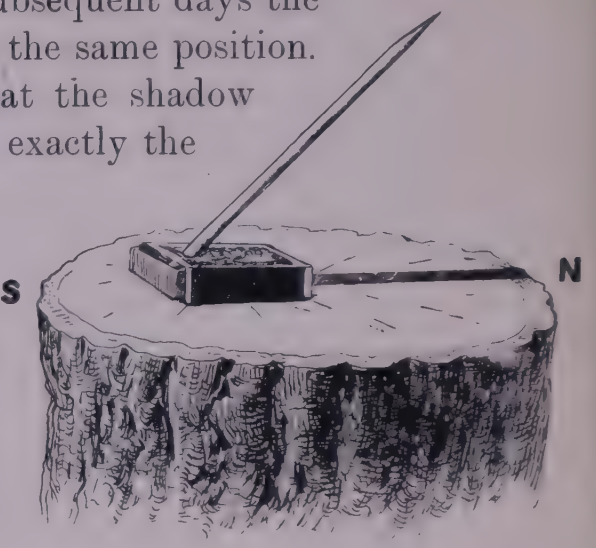

FIGURE 29.

As a matter of fact the axis of the earth is tilted, and a long series of experiments would enable you to determine at what angle the skewer must be placed in order that the position of the shadow may be the same at the same times of day.

By sliding out the match box from its cover (see figure 29) the skewer may be tilted as required.

A simple geometrical figure will show (see figure 30) that when the skewer or the style of a sun-dial is parallel with the axis of the earth, the angle made with the surface of the latter must be the same as that which represents the latitude of the place where the observation is made or the sun-dial is to be erected.

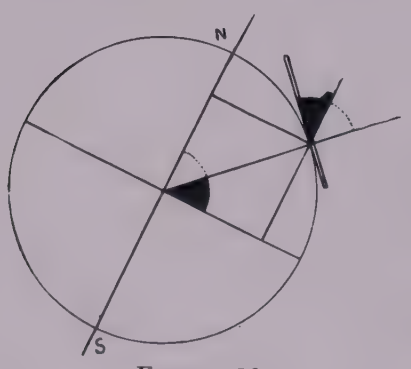

FIGURE 30.

The angles marked with dots are by Euclid, Book I., Proposition 29, equal to one another, and each together with a black angle makes up a right angle; therefore the blacked angles are equal.

Such knowledge may be assumed and the latitude itself taken for granted, or this may be practically determined in the following simple manner :—

Drive a peg into the ground, and to its top attach a little rod so that its end may be turned to any part of the sky. Early in the morning direct the pointer towards the sun (it will properly set when turned so that it casts a shadow no larger than its cross section on a piece of paper held behind it), and record the position of its end by driving a stake into the ground, so that the top of the stake shall just touch the end of the pointer.

Repeat the process several times in the day. The tops of the stakes will then make part of a circle whose plane is parallel with that followed by the sun. Lay a piece of cardboard (with one end upon the ground behind the peg) so that it touches the tops of all the stakes. The angle which the card makes with the ground represents the latitude required.*

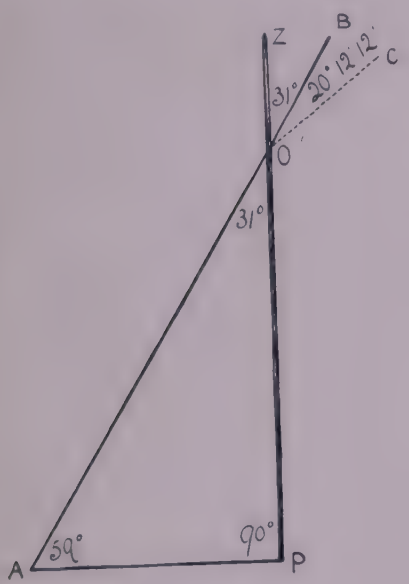

FIGURE 31.

At the Tiffin's Boys' School, Kingston-on-Thames, the latitude is taken by means of an upright knitting needle at noon, though in this case "the distance of the sun north of the equator" is obtained from the "Nautical Almanac." In figure 34 16·6 cm. is the height of the knitting needle, O P.

9·9 cm. the length of the shadow which it casts.

O B the sun's direction.

O C the direction of the equator.

The angle Z O B is 31°.

20° 12′ 12″ is the distance of the sun north of the equator.

Then the latitude = 31° + (20° 12′ 12″) = 51° 12′ 12″.

Having obtained the proper angle (figure 31) fold down the corner of a stiff piece of paper and draw a line A B, making the required angle with the doubled edge. Mark out other

* See "Physical Geography," by William Morris Davis and William Henry Snyder. Ginn & Co., 1898 (price 5s. 6d.), page 388.

lines as shown on figure 31, parallel and at right angles to the first, and cut along these through both thicknesses of paper. The dots show how a further cut may be made in order to render the style which we are constructing more elegant.

Fold along the line A B so that one thickness of paper stands out at right angles on each side, forming a base upon which the style will stand.

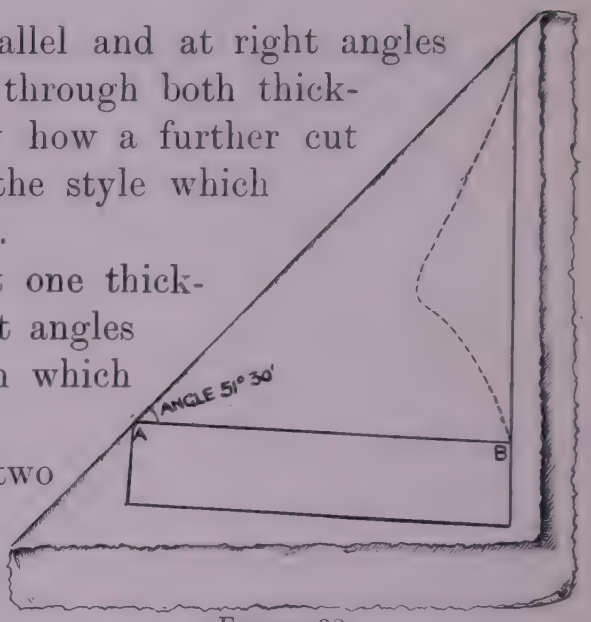

FIGURE 32.

On a sheet of paper describe two circles (figure 32) and draw a diameter in pencil. Make a slit of the same length as the base of your style and equally distant from each end of the diameter, gum the upper faces of the flanges on your style and push it through the slit from the under side of the sheet, to which the flanges will then stick.

FIGURE 33.

Lay your sheet upon the flat surface already used, so that the diameter drawn runs from south to north and the style points in the latter direction. Note where the shadow falls at the various hours of the day, and draw lines in ink showing the places and add the numbers as in figure 33.

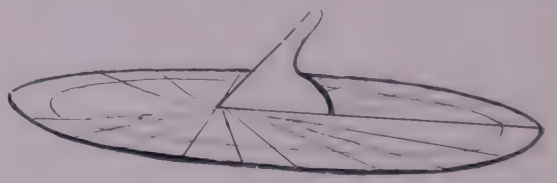

FIGURE 34.

Observations upon Clouds

In nature-lore which is the result of the nature-study of our ancestors, carried on from the most primitive times, when special apparatus was unknown, nothing perhaps plays a greater part than weather forecasts. Among these the form and movements of the clouds claim a large share of attention, and as Ruskin said to the

From a photograph by Commander D. Wilson Barker (by kind permission).

FIGURE 35.—*Cumulus* indicative of approaching showers.

author of a book on the subject to which we shall afterwards refer, there is hardly a better field for "simple observations without the use of costly instruments."

Very young students may gain much by watching the clouds and making series of sketches showing their change of form. "Animal

clouds" and the "Noah's Ark" will probably have the greatest attraction for them, not to mention "mare's tails" and "mackerel skies." In the next stage the main kinds of clouds and their significance should be more definitely distinguished. Masses of cloud (*cumulus*), streaks (*stratus*), flecks and wisps (*cirrus*), their varieties and intermediate forms, will be recognised. The heavy packs with

From a photograph by Commander D. Wilson Barker (by kind permission).

FIGURE 36.—*Stratus* pointing to fine weather.

sharp edges which denote rain, the "saw cloud" or dark and jagged "drought cloud" (*strato-cumulus*) which forecasts thunder, the cirro-cumulus indicative of change, and the soft edged, slow moving clouds denoting the continuance of fine weather, all form part of a most interesting branch of nature-study.

It should be remembered that, as Mr Samuel Barber has pointed out,* circumstances very much alter cases in connection with cloud forecasts, and he gives a list of conditions as to time of day,

* "The Cloud World" by Samuel Barber. Elliot Stock, 1903. Price 7s. 6d.

time of year, direction of the wind currents and so on, which must be taken into consideration when making a forecast.

Later on again work of really scientific value may be done and all the details of this and allied questions, considered.

The Study of Stars

Very little attention seems to be paid to observations which can be made upon the heavens without the help of a telescope, although it should be mentioned that a suggestive piece of kindergarten work consists in marking the positions of the stars which form particular constellations, upon pictures of the person or thing that they are supposed to represent.

The changes that take place in the position of the stars during a night or year would furnish material for a number of careful records.* As a special study the consideration of the heavens can be carried on at any season of the year, and more than one book dealing with work that needs no telescope† discusses the stars of spring, summer, autumn and winter under separate headings.

The fact that there is a tendency for attention to be confined to scientific work with elaborate apparatus, increases the opportunity for doing useful work in the direction indicated. In bringing this chapter to a close it will be as well to point out that there is much still to be added to our knowledge of clouds, of lightning, of various effects in the sky, of meteors, of eclipses, and a host of other interesting phenomena.

* A simple way of observing the movements of stars by means of pointers is given in the book, a physical geography, mentioned in the footnote on page 27.

† "Astronomy with an Opera Glass," Garret P. Serviss. Hirschfeld Bros., Eighth Edition. 1902. Price 6s. nett.

"Astronomy without a Telescope," E. Walter Maunder. Knowledge Office, 1903. Price 5s. nett.

OBSERVATIONAL LESSON III

Part I—A Seed Pod (*continued, 3rd Investigation*)

Preparations for Work

The dwarf bean plants must be placed ready for observation.

Directions to the Pupil

In the spaces reserved for the purpose make a third drawing of your chosen seed pod and fill in notes as before.

Part II—The Sun (*continued*)

Preparations for Work

The wooden bar will be required. (See Lesson II.)

Directions to the Pupil

According to the directions given in Lesson II., Part I. (page 20), the apparent position of the sun (if shining) is to be determined, and recorded upon the window by two students other than those who carried out the work before.

Insert the mark and date upon the plan of the window which you drew in Lesson II.

In similar fashion the shadow record on the floor may be continued.

Part III—A Sea Anemone

Preparations for Work

Glass dishes or beakers containing the anemones should be placed on the tables

ten minutes before the lesson, so that there is one specimen for every two or three pupils.

The anemones may be restored to the aquarium after the lesson.

Directions for Work

(1) As in the case of the plum, note down the size, shape (when expanded), and the colour of the anemone, and on the right hand page make an outline drawing, leaving a space for a more detailed sketch.

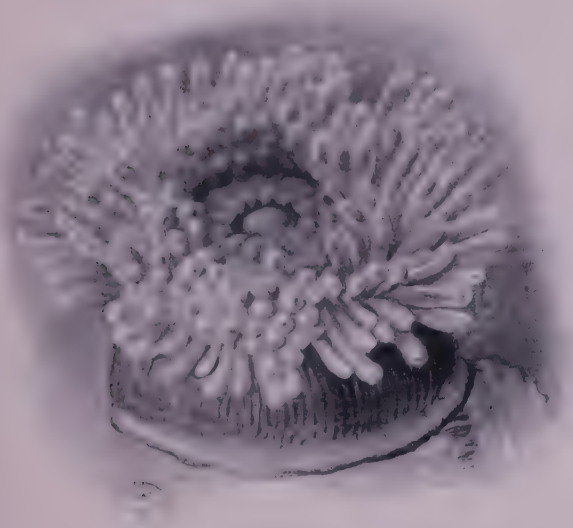

Figure 37.—A Sea Anemone expanded.

Figure 38.—A Sea Anemone contracted.

(2) Count the number of tentacles and see if you can find whether they are arranged according to any definite plan, recording the results of your observations as before.

(3) Count the number of apertures in the body.

(4) Touch the anemone and sketch the altered shape of the animal. What else do you notice about it?

(5) Drop a small pebble on to the tentacles and record what happens. Do the same with a small piece of meat or fish. (Note the different result and write down any explanation that may occur to you.)

Suggestions for Work out of School

Keep an anemone in a glass jar or dish containing salt water, taking care that it is as cool as possible, aërate the water by means of a glass syringe every morning. Occasionally fill up the vessel with distilled water to replace what is lost by evaporation. With a little care it is possible to keep anemones for many months in this way.

Note and draw the different positions which the creature will occupy from time to time, and note any other facts about it that you observe.

Search in ponds and slowly moving streams for hydras, the little fresh water relatives of the anemone, and compare the two together.

If you are lucky you may see how an anemone reproduces itself, especially if you have an aquarium and can keep two or three examples in the same vessel.

If you have a chance of visiting the seaside, look for as many different kinds of anemones as you can, noting the

(*a*) Size, shape and colour.

(*b*) Number of tentacles.

(*c*) Place where you found them, (that is to say how far below high water mark).

Then try and identify them from books and write their names against your sketches.

CHAPTER III

THE KEEPING OF A SALT WATER AQUARIUM—LIVING CREATURES OF THE SEA SHORE

The Keeping of a Salt Water Aquarium

There is perhaps no better means of arousing and sustaining interest in living creatures than the keeping of an aquarium. It must not be forgotten, however, that daily inspection and attention are necessary, if the aquarium is to be a success. Even hardy

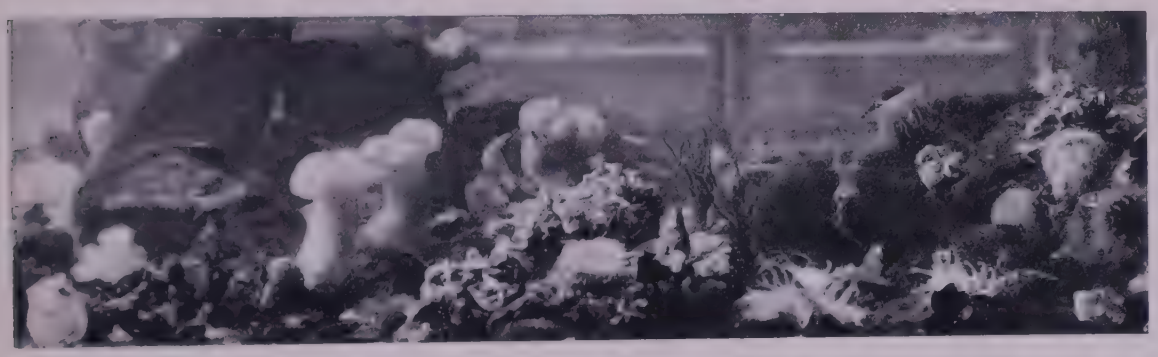

Figure 39.—A marine aquarium kept without changing the water for many years by Mr Sibert Saunders, of Whitstable.*

animals will soon die unless carefully watched and tended, while the successful keeping of small and delicate creatures so that a stock of them may be had at any moment will prove a very difficult task. It is, however, remarkable that aquarium keepers nearly always confine themselves to the use of fresh water, salt water being perhaps once tried, and then left severely alone.

* By the courtesy of Mr Sibert Saunders.

Seeing that most forms of animal life are far more abundant in salt than fresh water, we must assume that the rarity of marine aquaria is due either to the greater difficulties that attend their successful management, or perhaps to the belief that water from the sea can alone be used.

In many large aquaria the salt water is artificial, notably in the splendidly arranged tanks in Berlin, belonging to one of the finest aquaria in the world. The proper kind of salt is easy to get, and all that has to be done is to dissolve it in distilled water until the right specific gravity is obtained. Full directions as to how this may be done are supplied by the makers of the salt which is sold by all chemists (see appendix page 149).

As to the special difficulties which beset the keeping of a marine aquarium, the proper aëration of the water is doubtless the greatest. As a rule marine plants will not grow readily, but die after a few weeks. Various methods are given in the handbooks which deal with the keeping of aquaria, but perhaps the best and, after all, the simplest way, is to syringe the water for ten minutes at least once a day, taking care that the water carries down plenty of air bubbles at each stroke of the piston. Some naturalists are able with care to maintain their aquaria practically untouched for years at a time.*

The dangers of overcrowding are also great, and unless the utmost care is taken in this respect, the results will be disastrous. As a rule, indeed, unless the greatest caution is exercised, the inhabitants of salt water aquaria, kept at a distance from the sea, will after a few weeks be found to consist almost entirely of anemones, everything else having perished.

It will perhaps be thought that as the difficulties of keeping an

* See "Notes" by Mr Sibert Saunders in the official report of the Nature Study Exhibition, 1902 (Blackie 1903) and "Marine Aquaria" by R. A. R. Bennett, B.A., Upcott Gill (price 2s. 6d.).

aquarium are so great, it is useless to attempt this form of nature-study. This, however, does not at all follow. If the student makes up his mind to persevere, even after one or two failures, and above all to spend a few minutes *every* day in looking after his aquarium, he will be sure to succeed in the end in acquiring a most delightful hobby.

Living Creatures of the Sea Shore

Those who dwell by the seaside may have special chances of studying marine animals and plants. Much can be done by the edge of the rock pools when the tide is low, while temporary aquaria will at other times allow further and more continuous observations to be made. The creatures which one finds will, of course, vary a good deal according to circumstances.

You are, however, almost certain to find "five-fingers" or common star fishes, and some day when you have plenty of time, turn one over on its back in a pool and watch it slowly regain its original position with the aid of its tube feet with their small suckers.

The observations already suggested upon sea anemones may be carried further, and the ways of shore crabs can be investigated. Among molluscs, sea snails and their eggs may claim attention, or the particular denizens of some salt water puddle, their behaviour and inter-relations may form the subject of interesting notes.

We cannot go further into detail as to the subjects for study which may possibly present themselves, but we give two examples which are suggestive of the way in which they may be treated. The first deals with brief notes kept with those upon other creatures in a nature-study journal, and the second with a longer narrative of a single day's work.

Nature Journal *

1902. 26th Jan.	The Hermit Crab in my aquarium has grown too large for his shell, so yesterday I put another empty shell into his water. This morning while I was watching, the crab went up to the new shell, poked his claws as far into it as he could reach, turned it over, carefully examined it on all sides, then loosened himself from the old shell, and changed houses with great speed. He did not seem satisfied with his new shell, however, for when I came to look at him in about an hour's time he was back in the old one again.
11th Feb.	Yesterday I put another shell into the aquarium for the Hermit Crab, of very much the same shape and size as his old one, and this morning I saw him get into it. He went through the same process as when he changed shells before (January 26th), but he did not seem satisfied, as later in the day I found him in his old one again.
12th Feb.	The Hermit Crab has got into the new shell again to-day. I have put some large snail shells into the aquarium, but he does not seem to like them. I think they are too thin and light.

NATURE NOTES †

"At Siccar Point, where the cliffs project seaward in a great wall of rock, we left the grassy pathway and scrambled down to the sea. Under the cliffs we found a large roomy cave, reputed to have been used by smugglers in days gone by, which, although easily accessible and quite dry at low tide, has the sea for its floor and its walls hammered by the surf during the spring tides. In this cave, numbers of

* From a manuscript nature-journal (January 1 to May 18th, 1902), written and illustrated by Miss Eva Redwood, of Hastings' and St Leonard's College.

† By Mrs S. Douglas Wilson. From *Nature Notes*, the Magazine of Selborne Society (August 1903), pages 169-171.

martins had built their nests of brick-coloured mud, made from the red sandstone. Pretty little nurseries they were, with a half-moon shaped hole for exit and entrance. Our presence caused much consternation, and clouds of martins flew backwards and forwards before the entrance of the cave. Now and then a bold bird would dash in past us to pay its nest a hurried visit, and then dash out again to join the other alarmed parents. After a time the birds seemed to become accustomed to our presence, and openly returned to their nests, when an incessant chattering ensued, which suggested that the parents were entering into explanations with their little ones. In the flat conglomerate rocks to the left of the cave we came across a great pot-hole filled with water left by the tide. The hole was about two yards in diameter, and perhaps the same in depth, with a surface fringe of fine green seaweed, while lower down on the sides, bunches of coarse brown fucus had taken firm foot-hold. The water was beautifully clear, and showed quite plainly the bottom lined with pebbles and sea-worn pieces of rock. As our shadows fell across the pool we noticed some swift movements in its depths, but on looking to see the cause, nothing living was visible among the still stones. We sat ourselves down to watch developments, feeling quite convinced that some living creature had been there a few moments before. Presently from the shade of the fucus darted out three small gurnets about four inches in length, and immediately afterwards from under the shelter of the stones at the bottom some small crabs cautiously crawled out. From one of the larger recesses two large claws heralded the appearance of a lobster. He came out slowly and warily, and was followed by another and yet another of his kind. Soon the bottom of the pool was alive and moving with crabs and lobsters. Evidently, for some time past, the sea had not been high enough to reach this spot, for the rocks around were bare and dry, whereas, as far up as the then high-water mark, mussels formed a thick incrustation.

"As soon as the crustaceans emerged from their hiding-places they began to feed. With their claws they nipped off from the stones the scanty confervoid vegetation, and conveyed it to their mouths as though they were starving."

"They fed themselves very much like a child does, sometimes using the right claw, as a hand, sometimes the left, and sometimes both claws went to the mouth at once, reminding one of a greedy boy cramming his mouth with his two hands. One lobster caught hold of a long branch of brown fucus with his left claw, as though to steady himself, and with the right claw picked away at the seaweed and carried the portions to his mouth. Soon, however, a movement in the water washed the fucus away from the left claw, and beyond the creature's reach. The lobster, as soon as he realised

his loss, stretched out both claws towards the recreant weed so imploringly that the action seemed almost human.

The gurnets had many narrow escapes, for their armoured neighbours made attempts to seize them every time they ventured near.

From under a projecting ledge of rock a new form appeared—a starfish. Warily it made its way out of its hidden corner into the light. As it moved slowly along, its back was humped up and dome-shaped, for it seemed to use the tips only of its five arms in locomotion. At the edge of the recess and before, as it were, turning the corner, it lifted up one arm and kept it raised for some moments, as if to give a look round before venturing further. Finally, down went the arm, the disc flattened out, and the creature remained stationary during the rest of our watch.

We felt so sorry for the starving creatures in the pool that we crushed some mussels and dropped them in the water. It was quite amusing to see the commotion which followed. The gurnets dived after some of the dainty morsels, and having secured pieces of flesh to which particles of shell were attached shook them in their mouths as a dog does to rid them of the hard fragments.

The crabs and lobsters snatched at the food as it sank, and then rested quite solemnly, holding meat in one claw, while picking it and feeding themselves with the other. Their hunger satisfied, one by one they retired beneath the stones. Two lobsters, evidently strengthened and emboldened by their luscious repast, met face to face in front of a favoured recess. Instantaneously out came both pairs of eye pegs and the warriors glared defiance at each other. Both retreated a few steps, then advanced and glared anew. These actions were repeated two or three times, when the smaller warrior turned tail and hid himself beneath a stone a little distance off, while the larger one triumphantly took possession of the coveted nook.

Our interest in the pool disappeared with the lobsters and crabs, so we now directed our gaze seaward. Far away to the horizon the blue lines of the great strong sea extended, unbroken by sign of ship or sail. Near the shore, ridges of rock rose above the surface of the water like the back fins of some huge sea monsters, and over these ridges the waves played and formed a white lacework of foam which tumbled over in silvery cataracts and rejoined the sea. On some of these rock ridges sea-birds sat solemnly in rows. Four great cormorants rose from fishing and took possession of one ridge. As though at a given signal the four birds spread out their wings, stretched out their long necks, and then spun round and round like tee-totums, perhaps to dry themselves. They looked perfectly ridiculous during these gyrations, but finally they settle themselves down quietly, but with the wings still outspread.

OBSERVATIONAL LESSON IV

Part I—A Seed-pod (*continued, 4th investigation*)

Preparations for Work

The dwarf bean plants will again be required.

Directions to the Pupil

(1) Make and record your fourth series of observations upon the chosen seed-pod, which if necessary may be the last. (See lessons I-III.)

Part II—The Sun (*continued*)

Note :—

(2) If at the beginning or end of this and subsequent lessons the sun affords an opportunity of continuing the records begun in Lesson II, part I (page 20), advantage should be taken of it.

Part III—A Crab

Preparations for Work

Each student should be provided with a small living shore crab or an edible crab (see page 146) and a straight-sided dish of no great depth.

Note :—If a large crab is chosen, it may be necessary to tie each of its claws, in order to guard against accidents. The small swimming crab in which the last pair of "legs" is converted into paddles offers some slight variation, but it can often be caught in nets in very large numbers. An advantage in connection with this species is that it cannot move so rapidly as many others do when on dry land and can therefore be examined more easily.

From a photograph by Wilfred Mark Webb.

Figure 40.—The back of an ordinary edible crab.

DIRECTIONS TO THE PUPIL

(3) Carefully examine the animal, in connection with the headings given below in the left hand column.

Record :—	Make :—	Leave :—
The general colour The general shape The number of legs	Sketches of the front and back views of the crab	A space for a water-colour drawing

(4) Answer the following questions :—

Are there eyes ? Where is the mouth ? Is there a "tail" ?	Fill in and label the details as you go on, in your drawings above, and if necessary make enlarged pictures of special parts

(5) Describe six peculiarities of structure that you notice.

(*a*)
(*b*)
(*c*)
(*d*)
(*e*)
(*f*)

From a photograph by Wilfred Mark Webb.

FIGURE 41.—The under-side of an ordinary edible crab (female).

Fill in and label the details as you go on in your drawings above, and if necessary make enlarged pictures of special parts

(6) Give an account of the way in which a crab walks, and describe any other movements which it makes

Suggestions for Further Work in School

Very gently move apart the structures which look like miniature "barn doors" and lie just in front of the places where the claws are attached to the body. Describe and sketch what you see within.

The greater breadth of the tail in the female animal and the larger number of swimmerets with which she is provided (see figure 42) is a point that should not be overlooked.

Figure 42.—The tail of a female edible crab extended to show the swimmerets.

You may have wondered what was the cause of the bubbling that goes on just beneath the front of the crab's head when the creature is alive. In a dead specimen you can, by cutting away the "shell" at the sides, lay bare the "balers" that are present at the sides of the mouth and the gills over which a constant flow of water is maintained when the crab is in the sea.

CHAPTER IV

SPIDERS' WEBS AND CHRYSALIS HUNTING

Spiders' Webs

In autumn some kinds of spiders are very much to the fore, and may well be chosen for observation, yet it must not be thought that these animals can only be studied with advantage at that time. For instance, it is in the spring that the water spiders will make the silken bell to which they dive, in the ordinary aquarium, or better still in a small flat-sided jar where their movements can be successfully watched.

From a photograph by Frank Hughes, F.C.S. (by kind permission).

FIGURE 43.—The web of a Garden Spider.

In summer, as in autumn, the remarkable nests of many species are to be found among leaves and under stones, and the great house spider can be persuaded to make her home in a place where her movements may be seen. It is this animal which spins a platform-like cobweb across some corner, in the depths of which she lies in wait until the coming of her prey. A favourite lurking place, out-of-doors where

the "snares" are not likely to be disturbed, is behind a pipe which runs down from the roof where two walls meet. Here, spiders brought from other spots are almost sure to spin their webs one above the other. Many interesting experiments may be carried out with regard to the food which they will or will not accept. As the spider lies in shadow ready to pounce upon her prey, her eyes shine like tiny drops of quicksilver. The rapidity of her movements are almost startling, and it is often difficult to take a leisurely view of the animal. The introduction of a centipede, particularly one of the long slender yellow kind, into the web, will, however, give its owner considerable work to do in the open. For instance while two or three legs on one side are being freed by the spider with a view to carrying her capture into the den, a dozen more on the other, are becoming equally entangled.

From a photograph by Wilfred Mark Webb.

FIGURE 44.—The House Spider.

In order to keep one of these spiders in-doors in safety, all one has to do is to get a card-board box (such as those in which boots and shoes are packed) with a piece of thick paper doubled once or twice to form a "den," two paper fasteners with which to fix it in position (see figure 44), and a sheet of glass to replace the lid.

A number of pin holes should be made in the sides of the box so

that the air does not become stale. In this cage the spider will spin its web and flourish, if sufficient food is given to it. The advantage of such a cage is that the animal can be placed just where it may be wanted. Often the spiders even when kept in captivity (it is the females only which spin webs) will lay their eggs and wrap them in a silken case. It is possible that no glass after a time need be placed over the box, but this would be a matter for experiment.

From a photograph by William Farren.

FIGURE 45.—The Garden Spider.

Equally, if not more interesting, are the garden spiders, which spin large wheel-like webs (see figures 43 and 45). The accounts given by different observers as to the manner in which these "snares" are constructed vary somewhat,* and there is an opportunity of adding to knowledge in this respect as well as of obtaining useful practice in making detailed observations.

Although gossamer spinners are familiar enough in autumn, very little seems to have been recorded about them. The Rev. O. Pickard-Cambridge, F.R.S., tells us that myriads of small spiders, some old, some young, not belonging necessarily to any one species, produce the gossamer. Another of the few naturalists who have devoted themselves to the subject of spiders, to wit—Mr Frank Percy

* See "Through a Pocket Lens." By Henry Sherren, F.Z.S. The Religious Tract Society's Publications. Price, 2s. 6d. Page 100.

Smith has given us some notes upon the way in which this is done. The species whose methods he describes is a tiny jet black one found almost everywhere. In St James' Park, for instance, these creatures are common after the first frosts, and at the end of October or the beginning of November they crawl to the tops of railings, particularly those made of iron. Here they lift up the hinder part of their bodies, and, in a way still to be discovered, rapidly send out threads from their spinners. The slightest breeze carries off the end of these threads, and they are quickly paid out until they will bear the weight of the spider, which then lets go its hold and sails away.

A tangle may be formed here and there on the strand, making it more like a parachute, or if one is formed at the beginning of the gossamer it acts as a kite. Many interesting observations may be made as to the amount of silk one of these spiders can produce, the trial threads spun and cut adrift, and the difficulties with which the creatures have to contend.

From what Mr Pickard-Cambridge says it appears that some gossamer spinners weave snares or webs after they settle down, while others belong to groups which never do this. As to the gossamer itself, when the air is dry it flies high, and when this happens it is generally a good sign of settled fair weather, while the contrary is the case if the threads lie on the surface of the ground and on the herbage. The number of spiders which must at times be active may be judged from the following passage from Mr Pickard-Cambridge's letter :—

"When a partridge shooter in bygone days, I have often seen on a bright still September day these gossamer lines flying so numerously over the surface of the stubbles as to give almost the appearance of a floating sheet, shimmering as it waved in the sunlight, and the dogs were often seriously inconvenienced by the

collection of it on their lowered muzzles as they worked over the ground."

Chrysalis Hunting

Those who turn their attention to butterflies and moths may have the pleasure of seeing many handsome insects in full perfection if they catch them when in the resting or chrysalis stage. Mr W. Barnes of Reading, a naturalist who has spent many years of his life in the study of British insects, has very kindly furnished us with a few practical hints on the finding of pupae, which are embodied in the following remarks.

Apparatus

The only implements needed are a fern trowel with which to dig, a tin box filled with moss in which to place the pupae when found, and a sheet of India-rubber or waterproof cloth on which to kneel and over which to shake the sods of earth and rubbish.

Time of Year

Chrysalis hunting may be carried on all the year round, but the most profitable time will be found to be from July until the end of October and before the moles work, for they are active pupae diggers. If mole-runs be found round or under a tree you may pass it by, as the moles leave next to nothing in the shape of pupae after their work is done. October, however, has, as a rule, been found to be by far the best month.

Places

The bases of trees and especially those which stand alone in parks, or by the sides of woods and ditches will be found to be the most productive—but many pupae may be discovered in moss on old stumps, and on stones and banks.

Hedge-rows as a rule may be left alone, as neither those nor trees standing in them are worth the trouble of examination.

The best sides of the trees on which to work are those facing the North and East, as the caterpillars like to hide away from the sun and heat, and prefer a shady and fairly damp locality to a very dry and sunny one.

Pupae are generally found on the north side of trees if the ground has been much trodden on by cattle, as usually the soil is much softer and very friable in such places.

The trees most to be sought are the Oak, Elm, Ash, Wych-Elm and Alder, although you may dig round all kinds with more or less success. Some localities are much better than others, of course, but wet and clayey soil must be avoided.

Butterflies will be found "spun up" on grass stems, or their food plants, and under copings of walls or in thatch.

Hawks, Bombyces, Noctuae, and some Prominents are to be found at the roots of trees.

Geometers also, but many of these must be looked for in crevices of bark or twigs, under leaves, or on their food plants.

Pugs are mostly searched for under the bark of Hawthorn, Oak, Birch, Alder and Wild Apple.

Methods

Upon finding a favourable tree in good position, with plenty of corners formed by roots, start working about six or eight inches from the bole of the tree. Push the trowel (gently) into the ground, carefully turn up the sod or earth, and tap it (over the kneeling cloth), then pull it to pieces, when the pupae, if any are there, will invariably fall out; these you should carefully put into the tin box with the moss.

Every piece of the sod must be treated as described, and well looked through. Continue to work all round the tree, starting from the same distance away from it, and approach it carefully and gradually.

Some pupae are in the trees themselves, such as those of the Goat-Moths, Clearwings, and many others. These may be found by drawing the hand up and down the bark to find the soft place under which the pupa lies, having worked its way by the hooks on the segments of its body to a spot just under the surface of the bark, to be ready for the emergence of the moth.

Look over all rubbish collected at the foot of trees, as many good specimens may be found by so doing.

NOTE

When leaving a tree, always replace the soil in a neat manner, as it not only makes the place tidy, but it will also leave the ground soft and loose, so that in the future, fresh caterpillars may enter.

The searcher must always bear in mind that pupae hunting requires a vast amount of trouble and patience, and should the beginner find very little to repay him for the first day's labour, he must still continue day after day, until at length he is rewarded for the pains which he has taken.

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OBSERVATIONAL LESSON V

Part I—The Fall of a Sycamore Leaf

Preparations for Work

Each student must be supplied with a sycamore twig which bears leaves, some of which, at least, are ready to fall, and with a shoot of Tropaeolum (the so-called nasturtium) that has been left in boiling water for some minutes to render it transparent.

Figure 46.—A leaf scar on a sycamore twig.

Directions to the Pupil

First of all look at a single leaf.

(1) Record :—	Make :—	Leave :—
The colour of the blade The length of the blade The breadth of the blade The length of the stalk Any other details (which you can discover)	A labelled diagram of the leaf showing the parts set down in the notes	A space for a water-colour sketch

(2) Very gently pull some of the lower leaves on the twig until you find one which easily comes away.

Describe:—	Make :—	Leave :—
The end of the stalk The "place" on the twig	Diagrams	Spaces for sketches

(3) Discover why the leaf so easily came away, and write the reason under a special heading.

(4) Mention :—	Give :—	Leave :—
Any special structure near the leaf scar	A diagram	A space for a sketch

By removing other leaves (if necessary first cutting away part of their bases) endeavour to find out what it is that holds the leaf until the last moment.

Take a shoot of Tropaeolum (common "Nasturtium") which has been soaked in hot water. Look at the big veins in one of its leaves, hold the stalk to the light, and trace the continuation of the veins right down until they join with similar cords in the stem itself. Write down what you have done, and sketch the two connections you have traced.

FIGURE 47.

Find out how many rows of leaves there are on a sycamore twig. Draw three or four circles, one within the other, each of which is to represent one of the nodes or parts of the stem from which the leaves grow (see figure 47). Mark on each circle the relative position of the leaves. Draw two diameters at right angles, joining all the leaves, and note how much of a circle lies between each leaf and its neighbours in the next rows.

SUGGESTIONS FOR FURTHER WORK IN SCHOOL

Study other twigs such as Elm, Birch and Broom, on which there are different numbers of leaf rows.

SUGGESTIONS FOR FURTHER WORK OUT OF SCHOOL

See Chapters V and XIV.

CHAPTER V

THE COLLECTION AND IDENTIFICATION OF AUTUMN LEAVES—EVERGREENS

Autumn Leaves

In Autumn, when there are comparatively few things to be observed, one might do worse than to collect leaves from the ground, and to discover the kind of trees to which they belonged by comparing them with the few stragglers which have not yet fallen.

In order to determine the names of such trees which when found prove to be unfamiliar, it is necessary to find out one or two details with regard to the arrangement of the leaves upon the twigs, and to the formation of other parts of the plants.

The following synopsis * modified from a classification prepared for the use of his students by Mr David Houston will prove useful, and can be elaborated by the addition of details which are to be ascertained during the spring and summer.

* Field Studies in Natural History. No. 4, "Study of our Native Trees and Shrubs." County Technical Laboratories, Chelmsford.

SIMPLE LEAVES ARRANGED IN FOUR ROWS ON THE TWIG.

Not lobed.

Egg-shaped, almost lance-like (Fruit, pale crimson, seeds, orange).

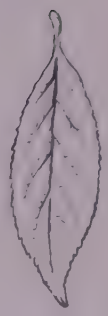

FIGURE 48.—SPINDLE TREE.

Egg-shaped, turning purple in early autumn.

FIGURE 49.—DOGWOOD.

Oblong, heart-shaped with downy veins.

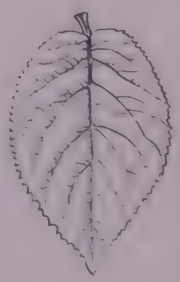

FIGURE 50.—WAYFARING TREE.

SIMPLE LEAVES ARRANGED IN FOUR ROWS—*continued.*

Lobed.

Rarely four inches across (Wings of the fruit horizontal; bark rough).

FIGURE 51.—LESSER MAPLE.

More than four inches across (Wings of the fruit divergent).

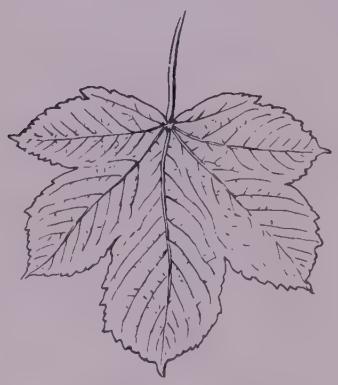

FIGURE 52.—GREATER MAPLE.

Three lobed.

FIGURE 53.—GUELDER ROSE.

COMPOUND LEAVES ARRANGED IN FOUR ROWS ON THE TWIG.

- Leaflets arranged like the fingers of a hand.
  - Leaflets, usually seven, narrow at the base.

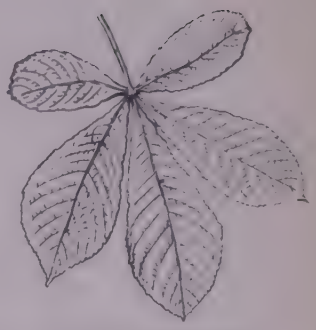

FIGURE 54.—HORSE CHESTNUT.

- Leaflets arranged like the barbs of a feather.
  - Leaflets, oblong, egg-shaped. (Berries black.)

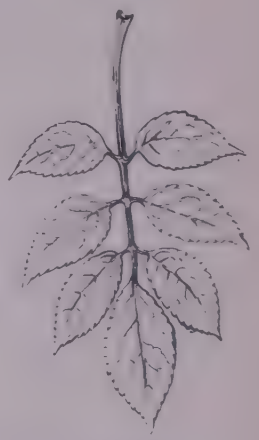

FIGURE 55.—ELDER.

  - Leaflets, oblong, lance-shaped. (Fruits or "keys" in drooping bunches.)

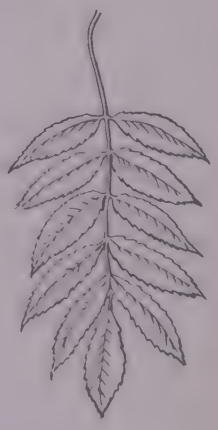

FIGURE 56.—ASH.

LEAVES ARRANGED IN TWO ROWS ON THE TWIGS.

Heart-shaped, unequal sided.

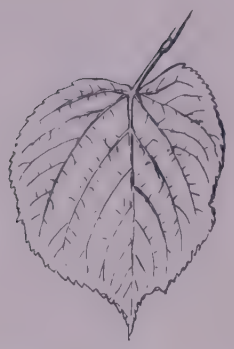

FIGURE 57.—LIME.

Rarely exceeding three inches in length. (Fruit with the seed above the centre.)

FIGURE 58.—COMMON ELM.

Exceeding three inches in length. (Fruit with the seed in the centre.)

FIGURE 59.—WYCH ELM.

LEAVES ARRANGED IN TWO ROWS ON THE TWIG—*continued.*

Lobed, roughly triangular, smaller lobes sharp pointed.
Fruits globular, hanging on slender stalks.

FIGURE 60.—PLANE.

Oblong, lance-shaped, over six inches in length, with a sharp saw edge, glossy on both sides.

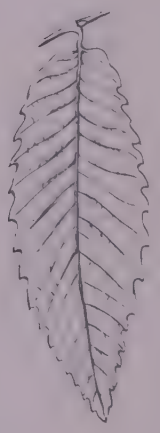

FIGURE 61.—SPANISH CHESTNUT.

LEAVES ARRANGED IN THREE ROWS ON THE TWIG.

Simple.

Roughly triangular, on slender stalks. (Bark silvery.)

FIGURE 62.—BIRCH.

Roundish (Bark black as are also the old fruiting cones which remain on the tree).

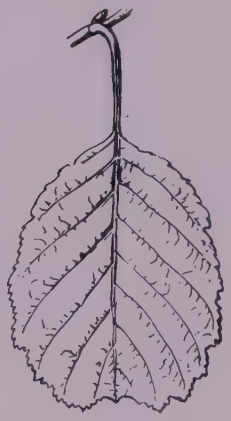

FIGURE 63.—ALDER.

Egg-shaped, glossy. (Buds very much pointed. Bark smooth, whitish.)

FIGURE 64.—BEECH.

LEAVES ARRANGED IN THREE ROWS ON THE TWIG—*continued.*

Simple—*continued.*

Broadly hea[r]t-shaped. (Fruit nu[t]s in leafy cups.)

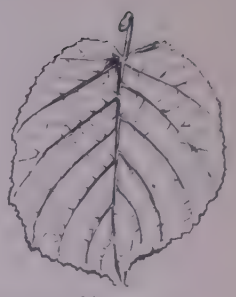

FIGURE 65.—HAZEL.

Ellipti[c]al, doubly saw-edg[e]d, hairy on the [u]nder side. (Bark smooth, light grey.)

FIGURE 66.—HORNBEAM.

Compound.

Leaflets, about nine, oval. (Bark grey, smooth.)

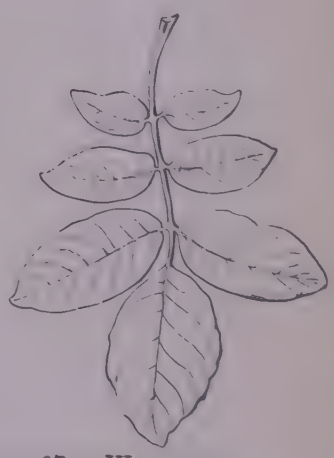

FIGURE 67.—WALNUT.

LEAVES ARRANGED IN FIVE ROWS ON THE TWIGS.

Simple, not lobed.

Egg-shaped (Branches black and spiny).

FIGURE 68.—BLACKTHORN.

Elliptical, doubly saw-edged.

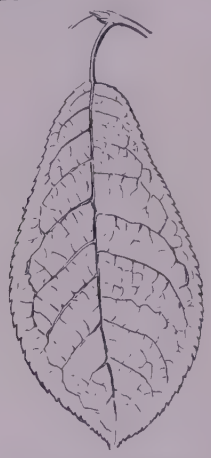

FIGURE 69.—BIRD CHERRY.

Oblong, egg-shaped, swellings at the base of the blade. (Branches slender.)

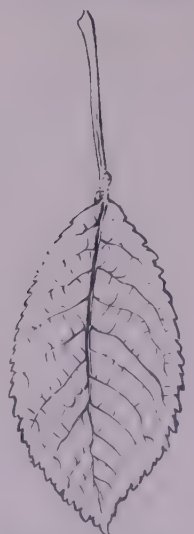

FIGURE 70.—WILD CHERRY.

LEAVES ARRANGED IN FIVE ROWS ON THE TWIGS —*continued*

Simple, not lobed— *continued.*

Oblong, egg-shaped (Fruit an inch in diameter).

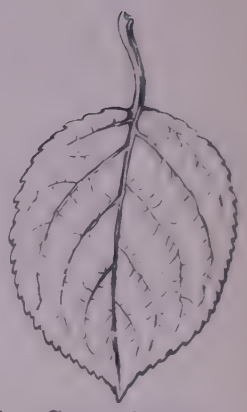

FIGURE 71.—CRAB APPLE.

Nearly round (Buds not sticky, bark grey).

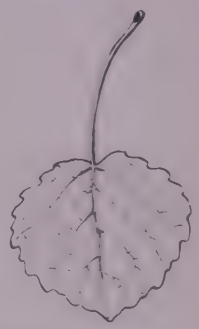

FIGURE 72.—ASPEN.

Triangular. (Buds sticky, bark grey.) (The leaves of the Lombardy Poplar are similar, but the tree is like those of the Black Poplar, tall and straight, and the branches are vertical.)

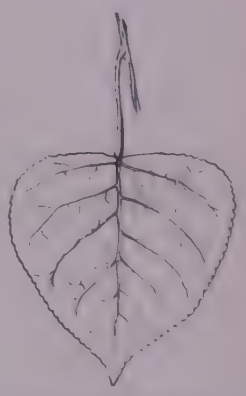

FIGURE 73.—BLACK POPLAR.

Simple, not lobed—*continued.*

Narrow, lance-shaped, with a long, tapering point (silky on both sides, catkins without a stalk).

FIGURE 74.—WHITE WILLOW.

LEAVES ARRANGED IN FIVE ROWS ON THE TWIGS —*continued*

Simple, lobed.

Oblong or egg-shaped, narrower at the base (Fruit, an acorn).

FIGURE 75.—OAK.

Egg- or heart-shaped, with six to ten lobes (Fruit small, greenish - brown and spotted).

FIGURE 76.—WILD SERVICE.

LEAVES ARRANGED IN FIVE ROWS ON THE TWIGS—*continued.*

Simple, lobed—*continued*

Egg- or heart-shaped, often deeply and coarsely lobed, white underneath. (Fruit dotted red.)

FIGURE 77.—WHITE BEAM.

Deeply divided (Branches in many cases reduced to thorns).

FIGURE 78.—WHITE THORN.

Lobed, on vigorous shoots at least, others with wavy margins, all cottony beneath. (Suckers freely produced.)

FIGURE 79.—WHITE POPLAR.

LEAVES ARRANGED IN FIVE ROWS ON THE TWIGS—*continued.*

Compound.

Leaflets in six or over eight pairs, downy beneath.

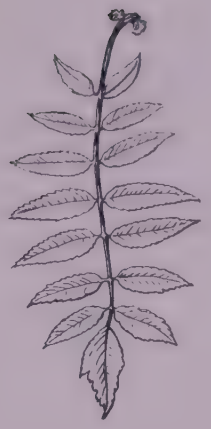

FIGURE 80.—MOUNTAIN ASH.

LEAVES ARRANGED IN EIGHT ROWS ON THE TWIGS.

Glossy, shining and spiny.

FIGURE 81.—HOLLY.

Some shrubs, such as the buckthorns and purple willows, will afford instances of transitional arrangement of the leaves.

The seeds of pines and their allies are not contained in fruits, but are to be found on the stems (yew and juniper), or in cones. Many ornamental trees which have been introduced into this country belong to this class. Only those which may be considered as belonging to this country are described below.

Evergreen. Two or three needle-shaped leaves on a tiny branch. (Besides the buds producing these, there are others forming the main branches; cones woody, bark rough, reddish brown.)

FIGURE 82.—SCOTCH PINE.

Not evergreen. Leaves narrow, clustered. (Branches hanging when young, cones with the edges of the scales turned back.)

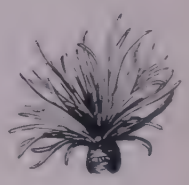

FIGURE 83.—LARCH.

Evergreen. Leaves marked with lines as long as broad, arranged in two rows, stalks with a half twist. (Seeds solitary, in a juicy cup.)

FIGURE 84.—YEW.

The Spruce, which is an evergreen, is practically naturalised. So-called Christmas trees usually belong to this species. Its cones are four or more inches in length, and the scales composing them are papery.

Miss Lulham, in her scheme of lessons drawn up for the Froebel Educational Institute, has suggested the consideration of evergreens and the way in which large masses of snow, such as would break the branches, are prevented from accumulating upon them. Details as to the way in which the leaves are placed, and the small surface which they offer are those which may well be observed.

Finally, the student should ask himself the question:—"To what is the fall of the leaf due?" If he has gained some knowledge of the functions of the leaf, and notes the time at which the fall begins in hot and temperate climates, he will probably soon come to the right answer.

In this connection also the change of colour of leaves in autumn should not be left unnoticed, although its explanation can hardly be discovered without recourse to a microscope. Further enquiries into the appearance and chemical nature of the colouring matter may very well be pursued.

OBSERVATIONAL LESSON VI

Part I—The Sun—(*continued*)

If possible, add further observations to those already made upon the sun.

Part II—A Mould

Preparations for Work

Small vessels furnished with lids, in which moistened bread has lain for ten days, and upon which mould is growing, should be put ready on the tables or desks so that there is at least one for each two students. It would be an advantage if the vessels are transparent (see Appendix, page 146). Some lemons covered with green mould should also be at hand, and a sufficient number of vessels (similar to those already mentioned), into which some melted gelatine and a little fruit juice has been poured and allowed to solidify.

Small slips of glass will also be needed.

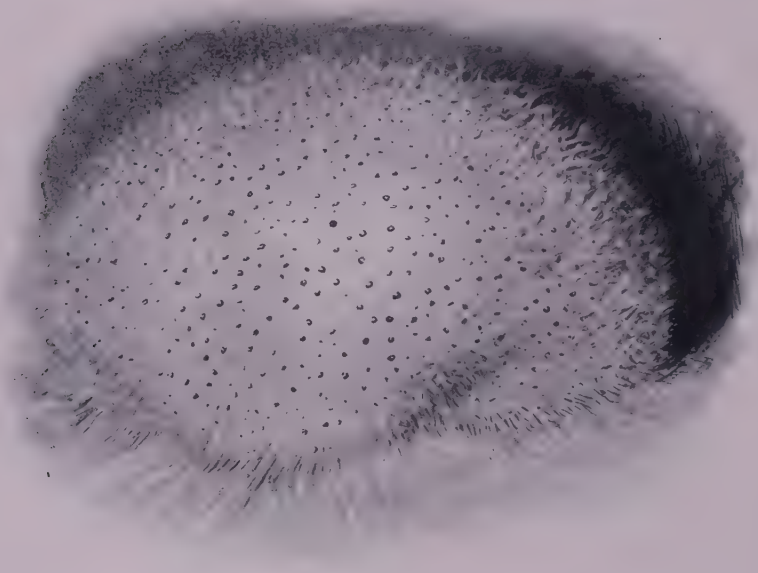

Figure 85.—A Common Mould.

Directions to the Pupil

(1) Carefully look at the various parts of the mould.

In your note-book mention :—	Make :—	Leave :—
(*a*) Of what the mould consists	A sketch showing details	A space as usual for a water-colour drawing
(*b*) The colour of a flourishing patch		
(*c*) Two other things you have noticed about it		

FIGURE 86.—A portion of a Mushroom bed showing the "landing" and the bed in section. A portion of the surface of the latter is also exposed. The threads or spawn of the fungus are seen, especially those which have contributed to the formation of some young Mushrooms.

(2) Take a little piece of the mould, and put it in a drop of water on a little slip of glass ; hold it up between your eye and the light, and choose a transparent part at the edge.

Record and draw as before what you see.

(3) Choose a piece from a more shabby-looking patch, and repeat the operation.

(4) Take some of the greenish dust from the mouldy lemon and scatter it on the surface of a dish which has been covered with gelatine.

Suggestions for Further Work out of Doors

See how many different moulds you can find upon various dead or living plants, and sketch them as you can see them with the naked eye. When you have begun more advanced work in natural history, you will find that the examination of moulds with the microscope is of considerable interest.

Part III—A Mushroom

Preparations for Work

Each student should have a newly expanded mushroom. Some deep seed-pans containing growing mushrooms and living spawn which have been specially prepared and kept until wanted plunged in a mushroom bed as indicated below, should also be provided.

Figure 87.
A common cultivated Mushroom.

Fresh horse manure should be obtained —seven weeks or so before the mushrooms are required—sufficient to make up a bed not less than a yard square and from nine inches to a foot in thickness. This should be kept under cover, and if too dry should be watered *once*. The material is damp enough, if, when squeezed it will bind together without the exudation of any moisture. The longer pieces of straw

should be removed (to be used, if necessary, for covering the bed), and the remainder of the manure made into a heap. After two days, the latter should be carefully turned so as to mix the outside portions with those inside, and the process repeated two or three times on alternate days. Having made the bed, break each of several cakes of spawn into six pieces and insert them edge downwards, so that they are closely in contact with the manure on all sides. Place two or three similar pieces in seed-pans filled with manure, and plunge them in the centre of the bed until the edge of the earthenware projects about an inch above the surface. This must then be covered with light loam, which forms the "landing" of the bed, until the manure is all covered to the depth of about an inch. A temperature of 70° Fahrenheit is that which must be generated at the bottom of the mushroom bed.

Directions to the Pupil

(5) Write down the various parts of the mushroom which you can identify, including the "cap" and stalk. Make a drawing of the fungus as seen from the side, and label the parts.

(6) Break off the head or cap: draw its upper and under sides, and describe them in your notes.

(7) Take a quarter of the cap: break it across and make a sketch showing the gills in section.

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No.....
Date.....

CHAPTER VI

FUNGI—SLIME FUNGI (MYCETOZOA)

After becoming acquainted with the structure and life history of the mushroom, the nature student should turn his attention to other plants of the same class, of which there are many thousand different species to be found in our islands. It is still a fact that the great majority of us look upon all fungi—with the exception of the mushroom, champignon, and truffle—as being poisonous and useless plants, to be destroyed whenever seen, or at best preserved as botanical curiosities. The notion that some toadstools, for instance, are not only harmless, but on the contrary to be considered as great delicacies—often far surpassing the mushroom in flavour—never enters the head. It is to be regretted that so much superstition still exists with regard to these interesting and useful plants. The nature student, however, will find that a study of fungi will amply repay him. To learn to know the various kinds, and where they are found, to acquaint himself with their structure and mode of growth, will offer an admirable exercise in out-door observation. If, moreover, he can conquer his prejudices, and learn by practical experience that many kinds are edible, he will be the means of introducing to his friends new and palatable forms of food, and proving, in one instance at least, the economic value of nature-study. Perhaps one of the chief attractions in hunting for fungi is the great variety of places where they may be found. Dense thickets, woods, shady lanes, open fields, rubbish heaps—all have their peculiar species. Not only this, but in places where it would be useless to look for any

kind of green plant, fungi of all kinds exist. Almost any damp surface offers a pasturage for them: ceilings, towels, old boots, rotten wood, cellar walls—to name but a few. Mention need not be made of the great part played by fungi in brewing, cheese-making, and other practical industries, while many of the diseases which destroy our cultivated crops: bunt, smut, potato-disease, turnip-mildew, are due to the attacks of a special fungus. Then again, the rapid growth of many species will excite wonder. In a meadow at Eton this year (1903), after the floods had subsided, a puff-ball was found growing on an old wooden fence, which increased from the size of a fives-ball to that of a foot-ball in a single night. This quick growth often enables fungi to exert great pressure on objects surrounding them. Paving stones have been lifted out of their beds by toadstools growing beneath them. Perhaps the best-known instance of this power is the circumstance which Sir Joseph Banks observed in his own house. A cask of wine was deposited in his cellar, and not examined for a space of three years. It was then found that the cask had leaked, and the wine supplied food for a gigantic fungus which had filled the cellar and carried the cask with it to the roof.*

Nothing more need be said as to the interests which are likely to arise from the study of fungi, but we would recommend the nature student to supply himself with reliable handbooks, such as those by Mr George Massee † and Dr M. C. Cooke.‡‡

* *Cf.* "British Fungi." By M. C. Cooke.

† "A Text-book of Plant Diseases." Duckworth & Co. 1903. Price 5s.
"European Fungus Flora (Agaricaceae)." Duckworth & Co. 1902. Price 6s.

‡‡ "Fungi, their Nature, Influence and Uses." 12mo. Cuts. Kegan Paul & Co. (International Scientific Series.) 5s.
"Introduction to the Study of Fungi." Royal 8vo. 1895. Woodcuts. A. & C. Black. 14s. 6d.
"A Plain and Easy Account of British Fungi." Out of print, but can be obtained for 2s. or 3s.

(*see over*)

He should then collect a few different kinds of fungi (toadstools to begin with) and identify them beyond doubt, after first sketching them and noting down the place where he found them. Coloured drawings, or still better, models may be made for a reference, while the actual specimens may be fairly well preserved in a mixture of formalin, alcohol, and water. (See Appendix, page 149.) By this means he will gradually become acquainted with the specimens of his district—an initial step in every study of the kind. Later on, after gaining experience in recognising different genera and species, he may put to the test the more practical values of fungi.

"Slime Fungi" (Mycetozoa)

There is one group of so-called fungi, the Mycetozoa, which in many ways is the most remarkable of all. Of late years the general tendency amongst naturalists is perhaps to place them in the animal kingdom, but their plant nature is on the other hand stoutly maintained by many botanists. They may be found in the active state, living in the shape of a slimy network upon decaying vegetable bodies, for instance rotten tree stumps and the spent oak bark of tan-yards. If allowed to dry up they become hard and brittle, and may be kept in this state for years, again coming into full activity after being kept in water for a few hours. The great interest of these

"British Edible Fungi." Coloured plates. 8vo. Kegan Paul & Co. 1891. 6s.

"Edible and Poisonous Mushrooms." 12mo. Coloured plates. 1894. (S.P.C.K.) 2s. 6d.

"Handbook of British Fungi." 2 vols., 8vo. 1870. Cuts. 25. Out of print.

"Handbook of British Fungi." Second Edition. Agaricini only. 8vo. Williams & Norgate. 14s. 6d.

"Illustrations of British Fungi." In 8 vols., 8vo. 1196 coloured plates. Published at 30 guineas, sells now at about 20 guineas.

"Rust, Smut, Mildew and Mould, Microscopic Fungi." Out of print, but can be obtained for about 2s.

"The Myxomycetes of Great Britain." 8vo. 24 plates. 1877. Williams & Norgate. 5s.

lies in the power which they have of choosing between different substances and creatures moving towards or away from what they can feed upon or what is hurtful to them. It is possible by suitable means to entice one of these networks (plasmodia) to move across a dry surface to a moist one.

The resting stage is characterised by spore-cases of various elegant shapes and colours which vary in different species. The collection, drawing, and identification of these fungi forms an interesting study which requires no great trouble, but as it entails work with the microscope, is beyond the limits of simple observational nature-study, though it is very suitable for those who have begun their scientific training.*

The question of resistance to drought, and the almost total cessation of life which some plants undergo, is one that has for a long time occupied the attention of naturalists.

Valuable experiments may still be done in this direction, to find out the exact length of time that can elapse, after the drying up process, before the creature finally dies. Some small animals will, it is known, exist in a dry condition for several years.

* The older pupils at St Margaret's School, Bushey, have worked upon the mycetozoa with considerable success.

OBSERVATIONAL LESSON VII

Part I—A Mould—(*continued, second investigation*)

Preparations for Work

(1) The "mould-gardens" which were "sown" during the last lesson will be wanted.

Directions to the Pupil

(2) Count the little patches of mould in your garden: make a plan of it and indicate the position of the growths, adding the date of "sowing" and drawings in the spaces reserved.

Part II—A Mushroom—(*continued, second investigation*)

Preparations for Work

The seed-pans prepared for the previous lesson should be ready, and a button mushroom, as well as an older specimen, should be in the hands of each of the pupils.

Directions to the Pupil

(3) Turn the button mushroom upside down: write down any difference between it and the older specimen that you may notice as it stands; put a sharp knife across the base of the stalk, and cut downwards, dividing the button into two equal parts. Sketch the inner face of one of the halves.

(4) See how the spawn or threads of the fungus (collectively called the mycelium) run through the manure and loam in the seed-pans, and how several go to form a single one of the more solid portions or mushrooms which appear above ground.

(5) Leave a space (of half a page) in your note-book. Take the cap of a second and older mushroom (away with you if necessary), lay it on a sheet of white paper, gills downward, and examine it after twelve hours. The black "spores" (similar structures to the green spores seen in the mould on the lemon) will have fallen on to the paper and made a pattern. Copy this into your note-book and record how it was obtained.

Part III—A Blindworm

Preparations for Work

Several living blindworms should be ready for handling and examination. As they move with difficulty on a smooth surface, there is little chance of their escaping from the table. One or two grass snakes may be at hand for comparison.

Directions to the Pupil

Note :—The blindworm is in many ways the most interesting of British reptiles, but it is delicate, and requires very careful handling. Do not be in the least afraid of touching it. It is absolutely harmless, and has never been known even to attempt to bite.

(6) On the right-hand page of your book, make a list of at least nine points which you notice about the blindworm.

(7) It is a lizard, not a snake. Why do we say this? Write down at least three reasons.

(8) How does it move?

On the left-hand page make a drawing of the animal as nearly natural size as possible, and add one of the head also, three times enlarged.

Suggestions for Further Work out of School

Blindworms may easily be kept in damp moss, and fed on earthworms and small slugs.*

Note :—A temporary vivarium may easily be made as follows :—

Take an oblong box of stout wood, and nail a board neatly across one-half of it. Cut a good sized hole into the piece you have fixed, and tack a piece of perforated zinc over it. Cut a piece of glass so as to exactly cover the part of the box still exposed; nail a little piece of wood on to each side; cut so that it projects a quarter

* Reptiles and batrachians should never be fed on the worm known as the "brandling."

of an inch over the edge; make a saw cut so that the glass will slide in and screw a wooden button on to the end of the box which, when turned, will prevent the glass from moving,

Watch to see if you can catch one of your blind worms casting his skin: write an illustrated description of this process, and of the method of feeding. Possibly young ones will be produced. The egg coverings are quite membranous, and the young appear a few minutes after the eggs have been laid. An interesting series of observations may be made upon the movements of the young ones as they free themselves from their coverings (see figure 88), and absorb the yolk sac of the egg.

From a photograph by Wilfred Mark Webb.

FIGURE 88.—A Blind Worm.

FIGURE 89.—The hatching of a blindworm from the membrane-covered egg a few minutes after it has been laid. (Observed by Wilfred Mark Webb, 1902.)

CHAPTER VII

BRITISH REPTILES

To many, the name "reptile" still suggests a slimy, ugly and dangerous creature. This fact is probably due to an inherited instinct that for generations has brought cruel treatment to a class of animals by far the greater number of which are not only perfectly harmless, but of great beauty and interest.

From a photograph by Douglas English, B.A.

FIGURE 90.—A Viper.

Even among field naturalists it is comparatively rare to find any one who has made these animals his special study, notwithstanding that although we have but few native reptiles, many points in their life histories still remain obscure.

This is the greater pity, since it is easy to keep all our reptiles—with the exception of the adder—in conditions to some extent resembling nature, and in which they will live and thrive, and in some cases breed.

It is not difficult to make useful vivaria in which these animals and amphibia may be kept successfully.

Details may be found in books which deal expressly with the subject.*

The animal lover who has ingenuity and time at his disposal can do much to add to our knowledge by devising and carrying out experiments as to the capabilities of his pets. Their powers of sight, their sense of smell, can be accurately compared and noted. The sensitiveness of their skin to light, their colour changes, and even such simple matters as the way in which they climb, offer many opportunities for useful observations.

Although adult adders will scarcely, if ever, take food in captivity, and hence cannot be kept indefinitely, it is not hard to procure females in July and August containing eggs in an advanced stage of development from which the young will shortly be hatched. On their appearance the mother snake can be removed, and although the young have never as yet been induced to feed, it is possible that their right food has not been given to them. At any rate, the more experiments that are made in this direction, the better; and ultimate success, should it come, would amply repay the trouble taken.

From a photograph by Douglas English, B.A.

FIGURE 91.—A Smooth Snake (Coronella).

* Such as, "The Vivarium," by Rev. G. C. Bateman, Upcott Gill, price 7s. 6d. The enthusiast in this direction may well make himself familiar with the work of F. Werner, Biol. Centralb., XXIII (1902), pp. 737-758.

Attention may be drawn also to reptiles in their natural conditions. Much remains to be discovered with regard to the habits of our six British reptiles,* and valuable information could be gathered by nature students as to the localities where they are to be found. This would be the first step towards finding the reasons why they appear in one place and not in another. Local sports and variations in colour again, to which it would seem that all our reptiles are liable, might also be recorded. So little do we know of the smooth snake, that any recorded observation by those who are fortunate enough to live in the counties where it is found would be of the greatest possible interest. It is alleged that this snake mimics to some extent the viper in its colouration, and adds to the illusion by flattening its jaws so as to give the head a broader outline, but proofs are wanting.†

From a photograph by Rev. S. Cornish Watkins.

FIGURE 92.—A Viviparous Lizard.

Lastly, we would urge upon nature students, who feel inclined

* See "Reptile Studies" by Dr Gerald Leighton, which appeared in the *Field Naturalist's Quarterly* in 1902.

† One of us has independently noted a similar habit on the part of some examples of the common snake.

towards the study of reptiles, to observe these animals especially in the light of their adaptations to surroundings. Although owing to the small number of British species of reptiles, such results as have been obtained in other countries * are not to be expected, yet it is impossible to doubt that careful scrutiny will bring to light many local differences of colour and habits. In the case of the amphibia which will be discussed in Part II, this is still more feasible than with the reptiles, since their numbers are greater and they are more easy to observe.

The following list will show the general distribution of reptiles in the British Islands :—

		England.	Scotland.	Ireland.
Lizards	Common viviparous lizard	Abundant	Abundant	Occurs
	Sand Lizard	In the South only	Unknown	Unknown
	Blind Worm	Common	Common	Unknown
Snakes	Grass Snake	Common	Unknown	Unknown
	Adder or Viper	In heathery Districts	In heathery Districts	Unknown
	Smooth Snake	Hampshire, Dorsetshire and Berkshire	Unknown	Unknown

* Such as for instance Dr Böttger's observations upon the special adaptations of reptiles to a desert existence (Zool. Garten, I, 1899).

OBSERVATIONAL LESSON VIII

Part I—A Mould—(*continued, third investigation*)

From a photograph by Wilfred Mark Webb.

Figure 93.—A Hedgehog.

Preparations for Work

The mould gardens will be required.

Directions to the Pupil

(1) Note any difference in the appearance of your garden.

Part II—A Hedgehog

Preparations for Work

Several specimens of the common hedgehog must be provided. They should, if possible, have become more or less accustomed to be handled. Some skulls of the animal should also be prepared.

Directions to the Pupil

(2) Watch the hedgehog when it is active.

Make notes as to :—	Add :—	Leave :—
How it walks	Rough outline drawings of the animal	A space for a detailed sketch or photograph of the hedgehog
The shape of its head		
The length of its tail		
Four other characteristics that strike you		

(3) Induce the animal to form its body into a ball.

Discover and note down :—	Make :—	Leave :—
How the hedgehog curls up What movements are made by the spines	Another sketch of the animal in this position	A space for a detailed drawing or photograph

(4) Examine a spine.
Describe it. Sketch it.

(5) If possible note any differences between a fore and hind limb, and draw both feet.

Suggestions for Further Work

Look at the skull of a hedgehog and describe the teeth. Find out from your living specimens what they will feed upon, and see whether the teeth are specially adapted for the work which they have to perform.

When opportunity offers, add notes as to the time of day at which hedgehogs feed when wild, the time of year at which the young ones are born, and their appearance.

Preparations to be made (possibly) beforehand, for Lesson IX

Note :—If the pupils cannot examine a horse during Lesson IX they should, in the meantime, fulfil for themselves out of school the instructions (see page 92) which refer to the living animal.

CHAPTER VIII

BRITISH MAMMALS

THERE are perhaps no animals about which more has been written than our native mammals, representing, as they do, the small remnant of what was once an extensive fauna. This is especially true of the larger forms, to which the sportsman, field-naturalist, and comparative anatomist have each paid particular attention from their respective points of view. Of the smaller and less conspicuous creatures, however, our knowledge is far less complete and in some cases extremely imperfect. It must not be supposed, however, that even with the best-known animals there do not remain many phases in their life history that are still unknown. It is impossible

From a photograph specially taken by Messrs Lascelles & Co.

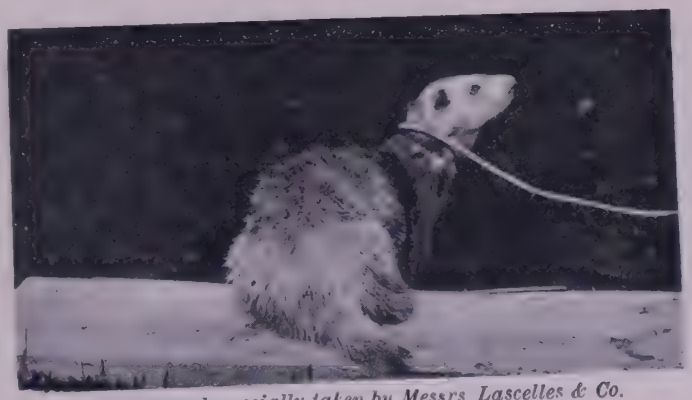
FIGURE 94.—The head of a male Wild Cat in the possession of Mr Alfred Heneage Cocks.

to tell what a field-naturalist of the type of the late Thomas Edward, or Professor W. J. Long, might not be able to add to our knowledge of such well-known animals as the fox and hare, to say nothing of shyer creatures like the otter and badger. On the other hand, there is much that we can only hope to learn by keeping and breeding our British mammals in captivity, and this is particularly the case with those which unfortunately are now very rare.

From a photograph specially taken by Messrs Lascelles & Co.

FIGURE 95. —A hybrid Stoat Ferret. 4th generation.

In the end one may be led to pay most attention to the animals of a single order, as has been done by an old Etonian, Mr Alfred Heneage Cocks, in the case of the British carnivora (including the seals). This naturalist has succeeded in breeding wild cats (see the frontispiece and figure 94), martens, and pole-cats, and has made many valuable discoveries about these animals. He has also produced four generations of hybrids between the stoat and the ferret after the results of the original cross came into his hands; the latter animal is a domesticated variety of the pole-cat.



From a photograph specially taken by Messrs Lascelles & Co.

FIGURE 96.—A hybrid Stoat Ferret.

This specimen was born with a stump tail.

In similar fashion nature lovers might devote themselves to the mice and other rodents.

The field-vole and bank-vole make interesting pets,* while squirrels, even though not kept captive, may be tamed sufficiently to enter the house to be fed.† Insectivorous animals like the mole and the shrew are more troublesome to deal with, owing to the almost continuous supply of food which they require. The keeping of British bats in captivity offers difficulties which would seem to be almost insurmountable.

From a photograph by Douglas English, B.A.

FIGURE 97.—A Dormouse.

The following general suggestions may perhaps be of use in indicating what will turn out to be useful paths of investigation.

The fox, as all know, is a member of the canine family, which has taken to burrowing, not a common habit among the dog tribe. He has, however, outwardly at least, not yet acquired powerful fore-arms like the professional burrowers, such as the badger or mole, and therefore often relies on enlarging a rabbit's

* See the notes by Mr G. T. Rope in *Nature Notes* (Bale & Danielson), vol. xiv, pp. 130-132 (June 1900).

† See "Wild Nature Won by Kindness," by Mrs Brightwen, pp. 126-130. (Price 5s. J. Fisher Unwin.)

hole, instead of digging one for himself. It would be interesting to find, by comparing the two, whether fox cubs are born with larger fore-arms in proportion than the young of dogs, which do not burrow.*

From a photograph by Charles Reid.

FIGURE 98.—A Squirrel.

The otter is another carnivore which is more allied to the badgers and weasels than to the cats and dogs, and shows many curious points of structure. The small eyes, narrow gullet, long-pointed tail are not generally found in aquatic carnivores. The seal, for example, has large eyes to see its prey readily in the water, a short capacious gullet to swallow its prey easily, and no tail. The impression conveyed by the otter is that it is a large weasel that has taken to the water, and has become an adept in aquatic life without much

* It is believed in some parts of the country that at times a vixen will cross with a dog, the resulting progeny being what is called a "cock-tailed" fox. Is this true?

corresponding change in its structure. The great length of time that elapses before the young go to the water, and the trouble which the old otter takes to teach them to swim, would seem to favour this view.

Evidence might be collected to prove whether or not the badger is really an enemy to game. Very contradictory statements are rife as to this point. Again, the alleged remarkable power of delayed gestation requires investigation. Female badgers are reported to have given birth to young after many months of solitary confinement. The same is said of the roe deer. Again, we have very scanty accounts from eye-witnesses, of badgers in their natural surroundings.

The pole-cat and marten are such rare animals that any observations relating to them are of interest, especially as to the reputed habit of the former of paralysing such creatures as frogs, toads and eels, by biting them through the brain, in the same way as the "solitary wasp" does the other insects which are stored up as food for her young, by stinging them in a nerve centre.

Further knowledge as to the alleged migration of the stoat and weasel is also to be wished for, and the experiment of breeding the former with the ferret should be repeated. Mr Cocks' hybrids will breed with the ferret, and then the offspring loses the special characteristics of the other progenitor.

The common hare is, again, an animal known to all, yet doubt exists as to the number of litters which it produces in the year. Professor Conrad* has produced a hare-rabbit hybrid (by bringing up the young ones of the two species together), which pro-

* "History of Creation," by Ernst Haeckel, vol. i, page 157.

pagates itself through many generations just as well as any genuine species. Notes are also wanted to complete our knowledge of many of the smaller mammals. The original account of the mole's tunnels and fortress given by St Hilaire has recently been entirely denied, and investigations on these interesting points are much wanted.

From a photograph specially taken by Messrs Lascelles & Co.

FIGURE 99. – Mr A. Heneage Cocks with one of his Stoat-Ferret Hybrids.

The young nature student will at first deal with such isolated observations as he may be able to make, and when it comes to the time when he can definitely take up a hobby he can choose the line of work which appeals to him most.

OBSERVATIONAL LESSON IX

Part I

A HORSE: OUT-DOOR STUDY

Preparations for Work

The loan of a horse must be obtained and the first part of the work carried on in an outside enclosure.* If this cannot be managed, it may be done out of school according to instructions given at the end of Lesson VIII. (See Page 85.)

Directions to the Pupil

(1) Jot down in a rough note-book:—

Any points of likeness or difference between a horse and a man. Make rough sketches of the fore and hind limbs and label the parts with their proper names adding in brackets those of the corresponding parts in a human being.

Part II

IN-DOOR STUDY

Preparations for Work

The skull, the bones of the fore and hind legs of a horse must be provided for each group of pupils, and the skeleton of a man should be at hand.

* In the scheme of lessons drawn up for the Froebel Educational Institute by Miss Lulham, the horse forms the subject of an out-door lesson.

DIRECTIONS TO THE PUPIL

In this lesson your attention is to be drawn to the fact that although at first sight the structure of a man is absolutely different from that of a horse, yet they are both formed upon the same plan. What that plan is and how the man and horse differ from one another in respect to it, you are to find out for yourselves.

(2) On the left hand side of your note-books write down the chief points of the skull of both the man and the horse, under the following headings :—

(*a*) General shape
(*b*) Size of jaws
(*c*) Position of eyes
(*d*) Number and position of teeth

Examine the bones of a fore-limb and give :—

(3) (*a*) Number of divisions in the limb
(*b*) Bones in each division
(*c*) Fingers in hand

Answer the question :—

To what part of the man does the "knee" of the horse correspond ?

(4) Do the same for the hindleg, and answer the question :—

"To what part of the man does the 'hock' of the horse correspond ?"

On the left hand side of the page :—

Make four outline drawings of the arm and leg of the man and of the horse respectively, and name the parts. Leave spaces for water-colour drawings.

Suggestions for Work out of School

Obtain the limbs of several small back-boned animals, for instance, those of the chicken and frog; cut away as much of the skin and

From a photograph by Wilfred Mark Webb; from the specimens in the British Museum (Natural History).

FIGURE 100.—The Skeleton of a Man and a Horse compared.

flesh as possible, leaving the gristle between the joints, and then soak the bones in water, scraping every now and then with an old tooth-brush. When they are as clean as possible, they may be left

exposed to the air and sun in order to whiten them or be put into water containing bleaching powder.

Make careful sketches of each limb and find out the names of the chief bones, marking them on your drawings.

The same plan may be made use of for all parts of the skeleton.

Work of this kind will be found to be the best means of introducing one's self to the study of comparative anatomy, and at the same time of forming an anatomical collection. It should be borne in mind that a knowledge of the structure of an animal or a plant can be of little real use if it does not lead to a comparison with that of other animals and plants.

A good exercise also would be to discover all the obvious points of difference between a donkey and a horse, and afterwards the resemblances or otherwise between these and other familiar animals of large size might be sought for and found. Such general work would be a good preparation for more particular observations such as are indicated in the following chapter.

CHAPTER IX

Domestic Mammals

COMPARISONS BETWEEN WILD AND TAME ANIMALS—ACCLIMATISATION —FERAL ANIMALS

Wild and Tame Animals

One of the great delights of country life is the opportunity which it gives of studying animals which for generations have been domesticated by man. Of these the dog, we must believe, was the earliest to be tamed, since in the evolution of the human race there can be no doubt that men were hunters before they became herdsmen and shepherds. As to the epochs at which our domestic animals were successively brought under man's dominion little definite is known, and speculation will not afford much help. Leaving such matters as these to the antiquarian, the nature student will concern himself rather with noting the differences between the structure or habits of tame animals and those of their wild relatives, as well as with the many signs which still exist, even in the most domesticated breeds, of their wild ancestry. Again the occasional "throwbacks" and reversions to an ancestral type, and the rapidity with which "feral" animals resume the characteristics of the wild species from which they spring, are subjects worthy of investigation. Furthermore, he will try to acquire some conception of the steps and methods through which the great structural differ-

ences between wild and domestic animals have been arrived at. Should he have the means and opportunities, the study of hybrids and the acclimatisation, if not actual domestication of wild forms,

From a photograph by Charles Reid.

FIGURE 101.—A Thoroughbred Horse, "St Simon."

offer a life-long interest of the greatest importance and value. The agriculturist and flockmaster, again, must make it their business not only to acquire an intimate knowledge of the various breeds of domestic animals, but to cultivate those powers of observation and

deduction which will enable them to make use of the slight variations that may appear from time to time.

It must not be supposed that the possession of a long purse and large estates is a necessary preliminary to investigation into this

From a photograph by Charles Reid.

FIGURE 102.—A Shire Horse, "Hiawatha."

particular subject. For an appreciation of much that we can learn from domestic animals, nothing is required but personal observation. The following suggestions may be of use in pointing out the sort of lines which our work should follow.

Examples of two or more very distinct races which are the result of man's care and selection, should be examined in detail and contrasted together. Afterwards, if it is possible, the wild or ancestral species should be considered in connection with each of the domestic varieties already observed.

The student should compare, for instance, a shire horse and thoroughbred together, and both with the primitive horses (see figure 103) recently brought to the Gardens of the Zoological Society of London.* It will then be seen how from a common

rom a photograph by Messrs Lascelles & Co.

FIGURE 103.—Wild Horses.

ancestor, two very different types have been produced. Some such kind of table as the following will show the most important points :—

* Whether these animals are really the ancestors of our modern horses, is undecided. The greater hardihood of ponies when compared with the horse is probably due to the fact that it far more closely resembles the original ancestor of the horse. The horse above fifteen hands is a far more artificial animal.

A Comparison between two Domestic Varieties of Horse.

	Shire	Thoroughbred
Shoulder	Straight	Sloping to allow of the forelimb being lifted high above the ground.
Pastern	Straight, hence the foot is more liable to disease from concussion. ("Side bone") Hairy *	Sloping, giving more spring and elasticity. No long hair.
Hind-quarters	Less conspicuously developed, that is to say, shorter from the point of hip to the hock	Highly developed, especially as regards the muscles of the "second (true) thigh."
Neck	Short and thick	"Long rein."

The same methods can be employed in contrasting the many breeds of dogs, horned cattle, and sheep; while in the case of pigeons, rabbits, and so forth, actual measurements may be taken of the various parts of the body, and comparisons made with domestic breeds. Such records are very scarce, and carefully compiled statistics of the kind would form a valuable addition to knowledge.

More popular, perhaps, would be a study of our domestic animals

* Probably the breed from which the shire horse has descended originally lived in the marshy districts of Flanders, while the thoroughbred is at least partly derived from the Arab.

in order to detect habits and instincts inherited from wild ancestors. To take but two out of a multitude of instances, tame rabbits kept in hutches, shake their paws before licking them preparatory to washing their faces. The interpretation of the movements is that they are intended to get rid of any soil that may be adhering to the animal's feet—obviously a habit derived from ancestors which burrowed in the earth. Horses are especially liable to shy at the rustling of tree tops, fearing, no doubt, that some carnivorous animal is about to spring upon them.*

It is not so much the province of this book to inform as to suggest ways of study which may in time lead to lines of investigation which are likely to prove of value. The importance of nature-study to those who have to deal with existing domestic animals is obvious, and its economic side should include the consideration of how additions to their number might possibly be made.

Acclimatisation.

Doubtless the eccentricities of our climate have something to do with the scant attention that owners of large estates in the country have paid to the possibilities of acclimatisation. With the example, however, set by the Duke of Bedford, the Hon. Walter Rothschild, Sir Edmund Loder, and a few other landed proprietors, it is to be hoped that much will be done in the near future. There can be no doubt that a number of animals such as the eland, koodoo, many antelopes and deer, the kangaroo and wallaby and beaver can all be kept in a semi-wild state in this country. Whether any of them can ultimately be added to the list of our food-supplying or draught animals is still uncertain.

* Other instances which may be taken as guides will be found in "Wild Traits of Tame Animals," by Dr Louis Robinson. William Blackwood. Price 10s. 6d.

Feral Animals.

Another field of investigation that may be recommended to the country dweller who is fortunate enough to possess the necessary requirements, will include "feral" animals. It is a matter of common belief that if domestic animals are turned loose to look after themselves, they will in a few generations either perish or revert more or less to the wild ancestral type. Accurate investigations, however, as to the time required for these changes, and as to how much the structure, as well as the marking, colouring, and so forth, becomes altered, are almost entirely wanting. Many interesting experiments suggest themselves, for instance, the turning loose of lop-eared and piebald rabbits, and of coloured rats, in places where they could revert to the wild state. In some cases it would be possible to experiment with larger animals, such as goats, sheep, and swine.* The nature student who takes up this line of investigation will find that he has almost the entire field to himself.

Experiments are also needed to throw light upon the possibilities which exist for producing animal hybrids, now that Prof. J. C. Ewart of Edinburgh, by his admirable work, has paved the way for future investigations.

It is to be hoped that the suggestions set forth in this chapter may especially appeal to those whose inclinations lean towards an agricultural and open-air life.

* In the New Forest there are "feral" swine which do not appear to have reverted.

OBSERVATIONAL LESSON X

A Bulb

Preparations for work

Each student must be furnished with a dry hyacinth bulb. Other specimens which have been placed in glasses, and which have begun to grow should be at hand so that there is one at least for each two students.

Directions to the Pupil

(1) Describe :—

(*a*) The colour and consistency of the outside covering.

(*b*) The appearance of the under side.

Sketch :—

The bulb from the side and from below

Leave :—

Spaces for finished drawings

(2) Remove the outer coat and make the same kind of observations as those which you made upon the outside.

(3) Lay a sharp knife across the base of the bulb, and cut it fairly in half. If necessary, slice away the bulb until the flower-head is quite distinctly seen in section.

Figure 104.—A Hyacinth bulb cut through.

Record :—	Make :—	Leave :—
(*a*) The number of white scales cut through	A diagram shewing the points discovered	Spaces for coloured sketches
(*b*) The number of green leaves		
(*c*) The shape of the stem		
(*d*) The size of the flower head		

(4) Examine a bulb which has begun to "grow."

Note down :—	Make :—	Leave :—
The place from which the roots spring and describe these	A drawing of the bulb	A space for a finished drawing

Record :—

The length of the shoot.

Note.—Leave spaces for a rough and a finished drawing to be added during the next lesson (Part I), and if necessary for others made out of school in the future.

Suggestions for Further Work in School

Compare the hyacinth bulb with that of a white lily and a tulip, as well as with the corm of a crocus.

CHAPTER X

HIDDEN PLANTS AND HIBERNATING ANIMALS

Hidden Plants

In the winter many plants rest. Some of these only lose their leaves, others "die down," and under the soil are their roots, runners, bulbs and tubers which, stored with food, are ready to produce a mass of foliage once more in the spring.

Those who do not mind hard work, may unearth the gigantic and grotesque roots of the white bryony, the only British member of the gourd family, and the climbing shoots of which are among the most elegant that this country produces.

As a rule, however, less extensive diggings will suffice to lay bare the roots of the wild carrots, the blue-bells and earth-nuts. A good exercise in discrimination will be to determine which of the resting structures are roots and which stems. Buds will be found on the underground part of "Solomon's seal," leaf scars on those of the Iris, and other evidence will be forthcoming in most cases.

Students who have begun chemistry or botany may care to investigate the various materials stored away in the underground structures, and may add to our knowledge in this respect. They will find it not difficult to learn and apply simple tests which prove the presence of sugars and starch, or to discover that something else, as in the "Jerusalem" artichoke, takes the place of these.

Much insight may also be gained as to the ways in which, beneath

the soil, plants often increase their numbers vegetatively, and without the intervention of seeds. Structures with similar purposes produced above ground, like the buds that drop from the lilies, and are not hidden, have a meaning which is not at first evident, and are excellent examples of sleeping plants.

Hibernating Animals

Not only may we satisfy the hunting instinct which still exists in most of us, by seeking for the places in which various animals have made their winter quarters, but we may also, a little earlier in the year, see the preparations which they make for their long sleep.

Incidentally we shall learn those species among insects for instance, which survive the cold season, and further, whether all individuals have the strength to do so or only the favoured females.

Certain butterflies which from time to time are thought to have left their chrysalides very early, pass the winter in some dry corner, and their very appearance, worn and weather-stained as it is, should tell their story.

"Queen" wasps are to be found in such places as under the bark of a dead tree, waiting until it is time to found a new colony in the Spring. The following observations* on the hybernation of the humble-bee made by Mr W. J. Webb, will suggest the kind of work that may be done.

It would appear that the bees make early preparations, for in the middle of August holes were noticed in a mossy bank on a lawn which sloped to near the north and was shaded by trees. "The excavations," Mr W. J. Webb says, "I at first took to be the work of 'dumble-dor' beetles. Some of the holes were half dug, others

* From a manuscript note-book, kept in the Isle of Wight (1854-1855).

evidently contained an inmate which had entered and closed the entrance by pushing back the earth which she had displaced. I pushed a straw through the loose earth, and putting my head near the ground, I could recognise the angry buzz of a disturbed humble-

FIGURE 105.—A Hibernating Humble-Bee.

bee coming from quite near the surface. Afterwards I saw a bee at work digging in one of the unfinished holes. This was one of the large 'queens' (of the black and red kind). She worked away for some days, sometimes leaving, I suppose, in order to feed, and at last

buried herself. There were four holes occupied, and two or three unfinished, all within the space of three square feet. From this I supposed that all parts of the bank were not suitable for the purpose. On digging into the bank I found that it had a thick covering of moss which was felted together, affording to the bees some protection from the frost."

"At the beginning of September I slightly opened one of the holes. I could see the back of the bee, this time one of the yellow banded species (see figure 105). She was moving about, seemingly at work, smoothing the interior of the cell, and several mites were climbing over her. I then closed the cell. In the middle of September, I opened another; the bee was quite lively, and seemed inclined to resent my interference. This example also was infested with mites. December 30th (1854)—I have this day again opened one of the holes and found the bee not at all torpid, but quite lively."

From a photograph by Wilfred Mark Webb.

FIGURE 106.—The Edible Snail and its winter lid.

"About the middle of the month of April (1855) the bee came out. I have always understood that the 'queen' humble-bees lived beneath the ground through the winter, but I should have supposed that they would have dug deeper holes in order to be further out of the reach of the frost."

Few pieces of work are more neatly done than the making of the winter lid, which closes the lid of the edible snail, the largest of our species (see figure 106), found most commonly on Chalk Downs.

These snails are easily kept and fed.* Not the least interesting feature of their hibernation is the method they adopt of burying themselves with the mouth of the shell uppermost.

Mr H. E. Forrest tells us, in a letter, of the way in which the dormouse makes its spherical nest as ascertained by his personal observation. The small creature works from the centre, and chiefly uses long strips of honeysuckle bark as material. Taking each piece by the middle between its teeth, the mouse retires to the inside of its nest where it turns over and over until the strip is smoothly laid around the central cavity. The nest is therefore built from within, and is not woven together as might be thought from a casual examination.

From a photograph by R. B. Lodge.

FIGURE 107.—The Nest of a Dormouse.

Considering the great loss of bird life during a hard winter, it seems surprising that nature, to speak figuratively, has not arranged for at least a few birds to pass the winter in sleep. The bat and the swallow may be seen any summer evening hawking together for insects, yet how differently do they behave on the approach of winter.

* Mr William Cole, F.L.S., has had a specimen alive for seven years.

OBSERVATIONAL LESSON XI

Part I—A Bulb—(*continued, second investigation*)

Preparations for Work

The growing hyacinth will be needed.

Figure 108.—An Oak Log cut across.

Directions to the Pupil

(1) Record the growth of the hyacinth since last lesson and sketch it.

Part II—A Log of Wood

Preparations for Work

Small lengths of oak log (bearing the bark) and of which one end has been made smooth should be distributed, one to each student. The limb of a tree about six inches in diameter is very suitable.

Directions to the Pupil

(2) Look at the side of your log.

Answer this question :—

Why are some parts of the bark rough while others are smooth ?

Make :—

A sketch of a small piece of bark

Leave :—

A space for a finished drawing

Record :—

(*a*) The width of your log

(*b*) The thickness of its
Bark
Heart wood
Sap wood

(*c*) The number of rings in the wood, and calculate the age of the trunk or limb from which your log was cut

(*d*) Any other markings or details of structure in the wood

Carefully make :—

A large diagram showing all the parts of the log which you have described and label them. If time does not allow you to fill in the details of the whole circle finish a quarter of it

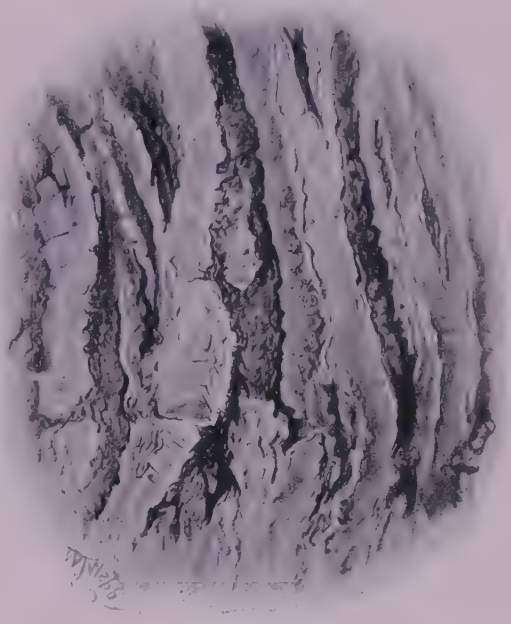


FIGURE 109.—Oak Bark.

SUGGESTIONS FOR FURTHER WORK

Compare the oak with a piece of elder stem, two or three inches thick ; and with branches of beech, ash and willow. Specimens of various woods may be collected, cut (1) across, (2) lengthwise, (3) tangentially, and then mounted.

CHAPTER XI

THE BARK OF TREES—THE CHARACTERS OF TIMBER

The Bark of Trees

We have already given a table which will help in the recognition of trees, more especially by the form and arrangement of their leaves. It is possible, however, to obtain from the colour, texture and growth of its bark, considerable evidence as to the identity of a tree, and what is more, some inkling as to the rate of its increase in size. If growth be slow, there will be few of the deep fissures which are often so obvious, say in the willow, because there is no sudden necessity for more room within the bark.

From a photograph by Wilfred Mark Webb.

FIGURE 110.—The bark of Spanish chestnut.

Some few trees get over the difficulties which a non-elastic

covering imposes upon them by pushing off the old bark from time to time and replacing it with new.

From two points of view, therefore, the subject of the external appearance of tree-trunks may be approached,—from that which merely seeks to make interesting observations, and that from which the name and nature of the tree is to be discovered. As we shall have again to mention the external appearance of trees, it will not be necessary to say more here.*

The Characters of Timber

There is that power of discrimination which comes from long practice, and is due to a recognition of certain details of which we are hardly conscious, and which many of us would be at a loss to describe. For instance, we recognise a friend, because we "know" him. In the same way a timber merchant "knows" the many different kinds of wood with which he deals. It is only recently that an attempt has been made to so describe timber, that anyone may determine a section of wood from words.

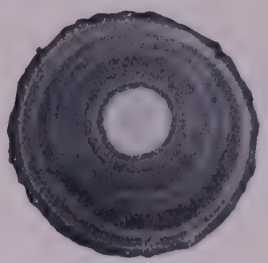


FIGURE 111.—Elder Stem, showing the wide annual rings of wood and the pith.

In our nature-study observations, we should always endeavour to be clear as to the actual points of difference and likeness between things in a series. The power of appreciating details of this kind is gained in systematic natural history, where the minute though often constant

* In an address entitled "Trees as a Means of Nature-Study," given by Mr John Evans at the Nature-Study Exhibition, 1902 (see the Official Report, page 167. Blackie & Son, price 2s. 6d.), there is much of value, although the work is carried considerably beyond Nature-Study proper.

features which distinguish one species from another, occupy the attention of the scientific student. Hence, it is sometimes said that no one can be a completely trained naturalist who has not busied himself with the determination of nearly allied creatures. Nature-study may well pave the way for such work in a general manner.

From a photograph by Wilfred Mark Webb.

FIGURE 112.—Section through a piece of Yew.

The description of the sections of wood ought to be made in detail, and when some botanical knowledge is acquired, the reasons for the differences in structure which show themselves, will be more easily recognised.

There are a number of points that will offer themselves for explanation. For instance, one may well wonder how it is that yew trees increase so in size and flourish long after they have become hollow. The interpretation which has been given, is that numbers of young twigs which grow from the outside of the trunk coalesce, thereby adding to its size, and forming a solid outer part. Figure 112 shows a section through a piece of yew which is made up seemingly in the way described.

Another instance may be given. The willow wood used in the making of cricket bats is sometimes marked or shows irregularities in the grain, and is termed "stainy" by the bat makers. The presence of the "stains" is by no means considered a defect

in a bat. They are, as a rule, put down to the borings of an insect, but a little trouble has enabled one, in some cases at least, to trace their origin to an incompletely healed wound (see figure 113). It still remains to be determined whether such wounds are due to a splitting of the bark through its whole thickness, caused by the rapid growth of the wood, or whether we must seek for some other explanation. We shall have occasion to speak again of wounds when discussing grafting in Part II, but it may here be said that a wound may persist for many years. Evidence of injury can sometimes be traced through the woody rings of a century or more, while a distinct scar is still evident on the bark.

FIGURE 113.—A section through a piece of "stainy" Willow wood.

A very striking series of specimens may with a little trouble be got together to illustrate, not only the rapid healing of wounds made intentionally, though with care, but also the harmful effects upon trees which often result from such as are made casually or which do not quickly close.

OBSERVATIONAL LESSON XII

Part I—A Bulb—(*continued, 3rd investigation*)

Preparations for Work

The growing bulbs will again be required.

Directions to the Pupil

Once more examine your hyacinth bulb. Measure the length of the shoot, sketch it as before, and date your drawing.

Part II—Water and Frost

Preparations for Work

A supply of river, spring,* and rain water should be at hand, the former taken when the stream is running high. Flasks containing the same quantity of each should be given to the class and arrangements made for boiling and filtering the water.

Directions to the Pupil

Look at each of the three samples of water labelled A, B and C, and note the differences. Pass each through a filter and note the result. Boil the same amount of the three kinds of water in three separate beakers and write down your observations. The three kinds of water are rain water, river water, and spring water.

* The best results will be obtained from springs in chalk and limestone districts.

Write down in your books which you think A, B and C are respectively, and give your reasons.

Make a table of the solid substances found in the water thus :—

	River water.	Spring water.	Rain water.
Solids removed by filtering.			
Solids which appear after boiling.			

Sketch the apparatus used.

Suggestion for Work out of School

It is quite possible if you take trouble, and have the necessary patience, to accumulate a great deal of solid matter by boiling a large quantity of water. The water should be always taken from the same source, and the amount weighed carefully before it is boiled. When sufficient solid matter is obtained, care should be taken that it does not stick to the side of the vessel in which the water is boiled by putting in some more water as fast as it boils away. The residue can then be weighed, analysed quantitatively, and an interesting percentage arrived at.

Occasionally an opportunity occurs for examining the copious deposits which are laid down from water in pipes, especially those connected with boilers and heating apparatus.

CHAPTER XII

Work for the Winter Holidays

MOUNTING SPECIMENS AS RECORDS OF NATURE-STUDY WORK—NOTES ON ANIMALS STILL ACTIVE—ROCKS AND FOSSILS

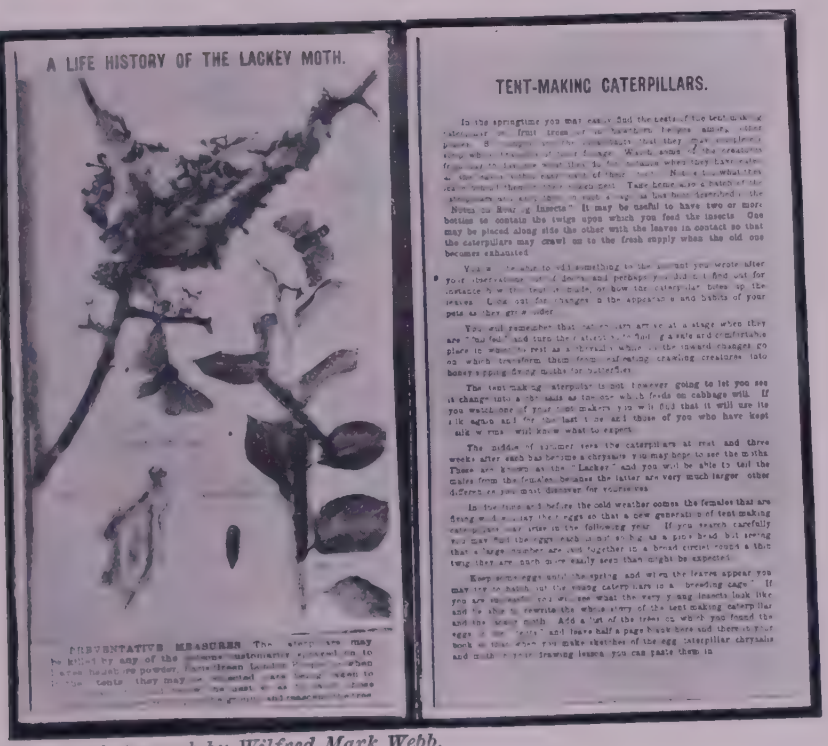
Mounting Specimens

The long winter evenings provide a time when much material obtained during the year may be arranged in suitable coverings so as to be of more or less permanent value. The specimens chosen may serve either as an interesting record of nature-study which has been carried out, or the gaps in the series will remind one of what still remains to be done.

For objects that are dry, nothing is better than the glass-topped boxes already mentioned in connection with fruits; and it may not be amiss to point out one or two of their advantages. In the first place, each specimen is kept quite separate from the others, as well as comparatively free from dust and injury, while its labels cannot very easily be lost. As the boxes are made to the same gauge, one can always introduce a new specimen into the series forthwith, without disturbing the contents of any other. The possibilities for display are obvious, and for teaching purposes the advantages of being able to hand round any one specimen in safety, are very great. A simple device, to wit, two small shelves, the lower one with a ledge on its upper side and the other with a ledge beneath it, enables a row of boxes to be fixed to the wall, and the

nucleus of a museum, at school or at home, is very quickly and cheaply obtained.

It is perhaps well to emphasize the fact that a jumble of assorted or unassorted curiosities, with meagre labels or none at all, is not to be looked upon as a museum in the modern meaning of the word. Nothing should be displayed without a definite purpose. In a



From a photograph by Wilfred Mark Webb.

FIGURE 114.—Museum Specimens and Labels.

nature-study section, everything should have a suggestive educational value, or be useful as a means of identifying such objects as are likely to be met with in its neighbourhood.

It is not advisable to stick down any specimen unless it can be easily replaced. Such things as fruits can be sewn to a card upon which the necessary labels are gummed. This in turn may be fastened

to the bottom of the box in a way that permits of its easy removal. Such things as shells, and even insects, can be placed upon white cotton-wool with advantage. The box should be filled to nearly the required height with common wadding, and a piece of *thin* cardboard cut so that it will fall easily into the box. Over this a somewhat larger piece of jeweller's cotton-wool should be laid, and before it is placed in the box, the edges of the cotton-wool should be turned beneath the card. After being put into position, the cotton-wool may be still further straightened by tucking it in with the points of scissors or forceps.

Should the specimen be large or heavy, a hole should be cut in the card beforehand, so that it may have a hollow in which to rest.

In museum work the object sought is to avoid over strong contrasts. Shining white backgrounds, as a rule, so force themselves upon the eye that the details of a dark specimen resting upon them are not evident. If the surface of the background is not smooth, as in cotton-wool or velvet, the glaring effect is a good deal softened. The same holds good in the case of white opal glass when immersed in methylated alcohol. A background should either be lighter or darker than the specimen, while the labels, especially if there be a large expanse of them, should be correspondingly darker or lighter than the background, but of a different tint from that of the specimen.

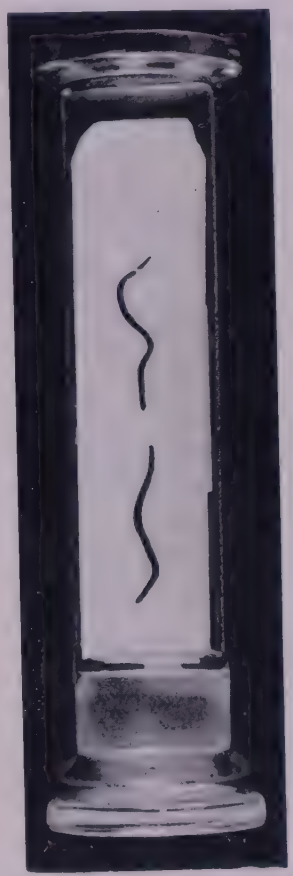
Such animals and plants as cannot be kept dry, may be mounted by being stuck* on to glass—opal, when they are dark, or on to ordinary glass, behind which a second piece of the required tint may be further placed—and kept in spirit.

For small things, cylindrical jars either stoppered or corked, may be adopted, in cases where the distortion does not matter. Flat-

* See Appendix, page 149.

sided jars are more expensive, and need special sealing,* but they certainly have not the disadvantages of cylindrical ones."

Methylated spirit can be used for many things. If it does not contain gum, as is the case now with that which is to be obtained at oil shops,* it can be diluted with water (the usual kind of spirit turns milky). Specimens which are liable to shrink considerably should first of all be placed for some days in 30% spirit, then transferred to 50%, and finally kept in 70%, as already suggested. Spiders, centipedes, millipedes, and woodlice are best kept in spirit. So also are earthworms. For such animals as frogs and toads* eggs, formalin (4% solution) is advisable, and a mixture of spirit, formalin and water is to be recommended for many fungi and succulent fruits.



From a photograph by Wilfred Mark Webb.

FIGURE 115.—A Museum Jar.

Scrupulous neatness must always be exercised and conventional arrangement departed from in details, when this can be done without detracting from the general orderliness. For instance, two centipedes placed in a narrow jar should be put one above the other in a straight line, but there is no necessity to fix each animal, stark and straight; natural curves will add greatly to the effect (see figure 115).

NOTES ON ANIMALS STILL ACTIVE IN WINTER

Where an opportunity for out-door observation occurs, it may come as a revelation that many of the smaller creatures are very much

* See Appendix, page 149.

awake—certain slugs, and some of their allies which possess shells, for instance. Insects too are by no means all dead. The question of birds and berries has already been mentioned, and it would repay consideration. Some interest may also be gained from tracing the footprints of birds and mammals made in snow, and then trying to tell what creatures made them.

From a photograph by Evan W. Small, M.A.

FIGURE 116.—A section of a railway cutting and limestone rocks near Ashbourne. Derbyshire.

ROCKS AND FOSSILS

After the work of frost in moulding the face of the earth has been watched, the sections through the ground which expose various rocks in the neighbourhood may be examined, and the remains of animals and plants which they contain may be collected. The exercise necessary to obtain these is often quite sufficient to keep the fossil hunter as warm as he cares to be. Quarries and railway cuttings, the banks of streams, and sea-cliffs are good hunting grounds for fossils. In the naming of these, if the work proceeds upon definite and scientific lines, help should be obtained from some local geologist.

OBSERVATIONAL LESSON XIII

Part I—A Hyacinth Bulb—(*continued, 4th investigation*).

Preparations for Work

Again get ready the hyacinth bulbs used in previous lessons.

Directions to the Pupil

Make similar observations to those recorded in Lesson XII, Part I.

Part II—A Branch

Preparations for Work

Distribute short lengths of thick horse chestnut branch bearing a side twig. (See figure 117.) The ends of the main stem should be cut on the slant.

Figure 117.—
A Sycamore twig.

Directions to the Pupil

Note down :—
The position of the buds with regard to each other—outer stem

Make :—
An outline diagram

Leave :—
A space for a finished drawing

Describe :—

The outside appearance of—

(*a*) A bud

(*b*) The surface of the bark

(*c*) Three kinds of marks which you can discern upon it

Determine and record in years the age of :—

(*a*) Tip of the twig

(*b*) Base of the twig

(*c*) Main branch

Add :—

To your diagram all the points observed

Label the parts and put in the age of the twigs and of the branch

Leave :—

A space for a finished drawing

In the last case determine the age of the branch from that of the twigs which it bears, and also from the number of rings in the stem.

Suggestions for Further Work

Other twigs should be examined which have their buds arranged differently and the work described in Chapter XIV may be carried out.

CHAPTER XIII

RAMBLES TO SEE THE EFFECTS OF WATER ON THE LANDSCAPE— THE MAKING OF RELIEF MAPS

Rambles to see the Effects of Water

Most of the present features of the earth's surface are due to the continued action of water in some form or other. That is to say, the hills and valleys, tablelands and plains, which characterise our English scenery, have all been the result of forces, which act so slowly that a lifetime is often too short to trace the least effect. It must not be thought, however, that for this reason it is useless to try to see for ourselves how this great process of earth-carving is brought about. Far from it. If we keep our eyes open and use our imagination, we shall soon be able to understand how it is that geologists have been able to write the past history of our landscapes. Let us take three common events and see what we can learn from them: a highroad after a heavy shower; a stream in flood; and a sea cliff after a storm. A well-engineered road will generally be found to be higher in the centre than at the sides. After heavy rain, tiny rivulets may be seen running from near the centre of the road to the gutters on each side. In fact, the middle of the road acts as a watershed. Look at the little streams, and you will notice that they have cut shallow grooves in the road at the bottom of which gravel can be seen; while in the gutter there is often to be found an accumulation of sand. The streams, in fact, have washed the lighter

parts of the road into the gutter. Instead, now, of a road, imagine a mountain chain, and you will at once realise how streams rise on either side of the ridge, and wash down the soil into the plains on either side: nay more; each of the little rivulets may often be seen to be an exact copy of a very great river, consisting first of many tributaries joining to form one which eventually breaks up into

From a photograph by Charles Welch.

FIGURE 118.—A valley showing the windings of the river which made it. The "Happy Valley," Mourne Mountains.

several, and runs through a delta of sand. Just as the rivulets tend to level the road and gradually wash it down into the gutters, so the ultimate action of streams is to cut down and level all uprising ground and carry the detritus to the sea. Then again, some roads are paved with cobbles in the middle. The action of the rain will affect the sides of the road more than the centre, causing the cobbles to stand up, perhaps an inch or two, above the rest of the surface, so

that fresh sand or gravel will have to be thrown down on either side. The same effect on a large scale in nature causes ridges of hard rock to stand up as hills or "escarpments" over plains consisting of materials more easily washed away. The Chiltern and Cotswold Hills are good instances of this action. Then again, look at a stream during and after a flood. The water rushes along bearing a much greater quantity of soil, so that it appears dirty. As it overflows its banks it deposits a good deal of it on either side, thus forming a plain, through which it deepens its channel as it goes along. Many of the great plains of the world have been formed in this way, while the remains of former plains at higher levels may be seen in the ridges and terraces which so often strike the eye of the observer as he walks along a river valley.

A storm at sea is perhaps one of the grandest sights of nature. The thundering of the breakers on the shore will stir the dullest imagination. Walk along a cliff after a great storm, and you will almost certainly notice that its appearance has altered somewhat since you last saw it. Often you will notice that great pieces of rock have been broken off, and lie half buried in the water. It is not difficult to realise that the sea acts as a great destroyer of the dry land, continually sawing round and round, and depositing the materials it has broken off, so as to form an ever increasing shelf round the coast. We know that the whole of our British Islands are resting on such a shelf, and were once far more extensive than they are now.

Nothing, perhaps, appeals more to our sense of the marvels of nature, when we realise that the whole surface of our globe has been gradually brought to its existing shape, not by great catastrophes and sudden eruptions, as was previously supposed, but by the accumulated effect of processes which are going on every day and all day around us.

The above cases are three out of any number of instances that

might have been chosen to illustrate some of the effects of moving water. Wherever the nature student may live he will find opportunities for gaining knowledge as to the past history of his district. If he live in a chalk country, for instance, it is perhaps the absence of water that will strike him, rather than its powers in affecting the land. Let him ask himself, what becomes of the rain water? why there are so many valleys if there are no streams to cut them? why do these valleys, when traced to their sources, usually begin as large circular areas? why the soil is so scanty? and he will at once be confronted with a host of interesting problems.

The Making of Local Relief Maps

A useful way of recording observations upon local scenery is to make a relief map. There are several ways in which this may be done. A model may first of all be made in clay, and a mould prepared and a cast taken. Plasticine may be used, or the highest points may be indicated by pins or pieces of wire driven into a board, and the map built up by sticking on bits of paper. A very satisfactory way seems to be to make a kind of "papier-mâché" * for the purpose. Newspaper is torn up into little pieces, and put into a copper half filled with water. After this it is boiled as continuously as possible for three days. The paper may then be worked up into a paste that can easily be manipulated. The map is built upon a board, along the edges of which a few tacks are placed to prevent the material from falling off. The drying process takes several days, and may be carried out in front of a fire or in the sun. After this, the surface should be painted, and different colours adopted for roads, fields, woods and so on. It need hardly be said that most heights and depths must be exaggerated to appear on the map at all.

* This was devised by Mr Edgar W. Brown, of St James's School, Weybridge.

OBSERVATIONAL LESSON XIV

A Growing Bud

Preparations for Work

To each student or pair of students give a small cabbage with a solid "heart."*

Directions to the Pupil

(1) Cut off a piece from the base of your cabbage stalk so as to make it quite level.

Note down :—

The width of the pith
The number of woody rings

Make :—

A diagram of the cut surface of the cabbage stalk

Answer the question :—

Is there any bark ?

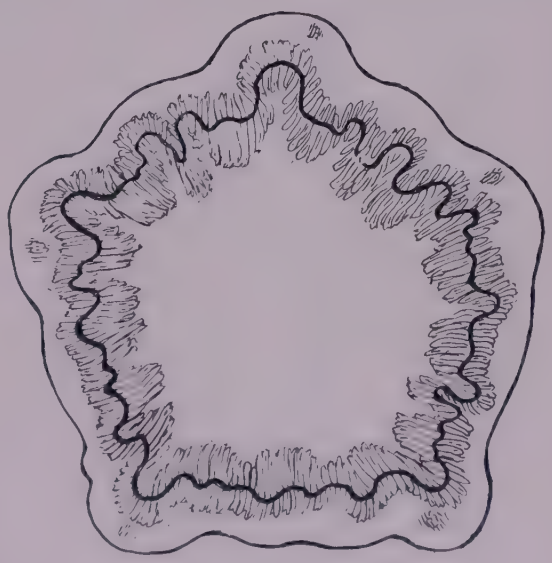


Figure 119.
A Cabbage Stalk cut across.

(2) Cut the cabbage in half, beginning with the stalk and keeping as nearly as you can to the middle.

Make notes as to :—

The size and colour of the cut leaves

Make :—

A general diagram

* A Brussels' sprout would do as well.

Look once more at the cut end, and trace the ring as it is continued in section up the stem and see if you can find a branch of it running into a leaf

Label :—

Your drawing. and put in details as you proceed with the lesson

Answer the question :—What is this branch ?

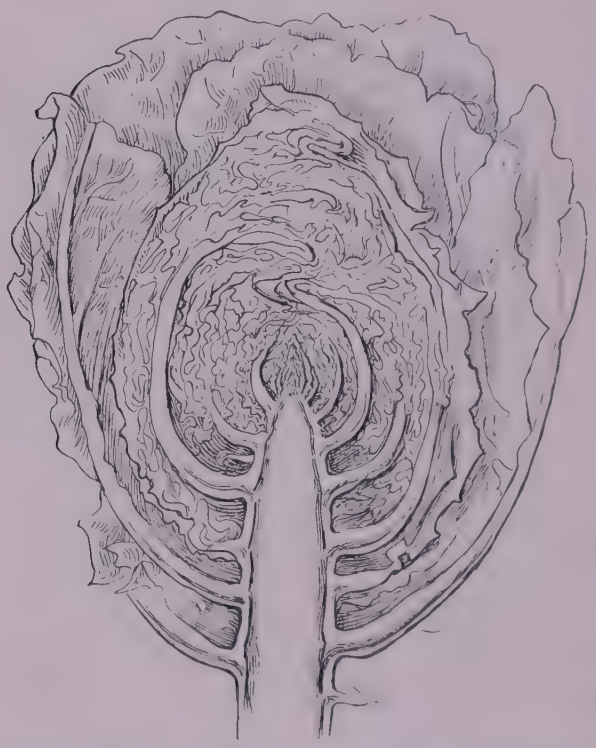


FIGURE 120.—The section of a Cabbage bud showing the connection between the leaves and the stem.

Note.—Refer to your work upon the fall of leaf (see page 52).

(3) Cut a leaf stalk across.

Describe :—

(*a*) Its shape

(*b*) The number of branches from the wood of the stem which appear

How are these arranged ?

Make :—

A diagram

(4) Discover how it is that a bud forms the compact structure that it does, and what happens when the bud begins "to open."

SUGGESTIONS FOR FURTHER WORK

Carefully open the buds of the horse chestnut in order to compare them with the cabbage.

CHAPTER XIV

TREES IN WINTER

Trees in Winter

When the leaves have fallen, a good opportunity exists for studying the form of trees, particularly as to their manner of branching. Drawing or photography may be employed to record one's observations, and care should be taken to mark the exact point of view or spot from which the picture is made, so that a similar one can afterwards be added for comparison when the leaves have once again appeared.

From a photograph by Reginald Weaver.

FIGURE 121.—A Plane Tree in winter.

We need not dwell upon the photography of trees in winter; it offers little difficulty and needs no particular hints or directions. In drawing, it is advisable to proceed in the following manner:—

First of all, mark out by means of four dots, the relative height and width of the tree in the space which is to be devoted to the drawing of it; taking care however to leave a fair margin all round. Having done this very lightly, sketch in line the general form of the tree (see figure 122), within the dots, and mark out the trunk together with the main branches (see figure 123). The latter must be very carefully put in, and when this has been done satisfactorily, the smaller branches may be added (see figure 123). Lastly, the twigs should be drawn, and the ends of these will come just within the first-made marginal outline which can then be rubbed out.

In simple nature-study, it will be enough to learn the shape and general appearance of the commoner trees, but it may be of interest to carry this work a little further. For instance, it is easy to find out many of the immediate reasons for certain familiar forms, though why the trees have assumed them is a more difficult problem. The varied arrangement of leaves upon twigs has been considered earlier in the book (Chapter V), and as the buds which are to produce new branches arise from practically the same spots as the leaves, it follows that we can make a model to illustrate any method of branching which results. In nature, however, the form of the tree will not be exactly the same as that of the model. Many buds do not develop, branches die, and species which have the same kind of leaf-arrangement may look very different owing to the direction in which the twigs grow and the distance between the points from which neighbouring ones spring.*

* Some interesting suggestions may be obtained from the series of articles by the Rev. W. H. Purchas in volumes ii. and iii. of "Science Gossip." New Series (1895-1897.)

FIGURE 122.

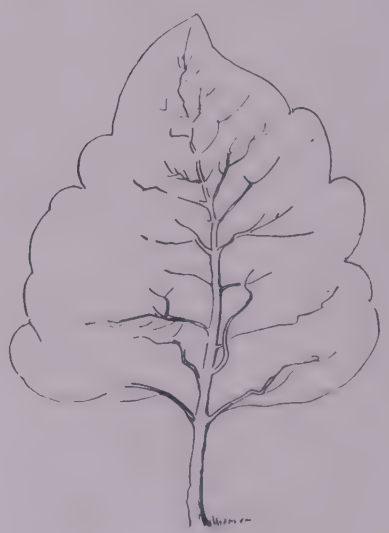


FIGURE 123.

FIGURE 124.

OBSERVATIONAL LESSON XV

A Seed

Preparations for Work

The following specimens must be available. Dry dwarf beans, and others that have been soaked, others again which have just opened.

Directions to the Pupil

(1) Describe :—

(*a*) The colour of the bean seed

(*b*) The shape of the bean

(*c*) Any marks upon it and other details you discover

Make :—

A sketch of the seed

Leave :—

A space for a finished drawing

Figure 125.—A Dwarf Sugar Bean (Sutton's).

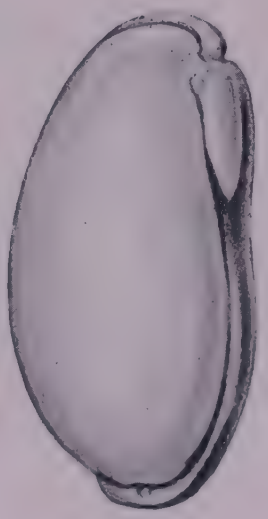


Figure 126.—A Bean with the skin removed.

(2) Take up a soaked seed

Note :—

Any differences between the soaked seed and the dry one

Make :—

A sketch

Leave :—

A space

(3) A bean which has just begun to sprout
(4) Peel the skin from a *dry seed*

Describe :—	Draw :—	Leave :—
The young plant as it appears within	What you see	A space

(5) Peel a soaked seed, remove a lobe

Describe :—	Make :—	Leave :—
What you see	A sketch	A space

(6) Peel a sprouted bean and label the parts in your previous

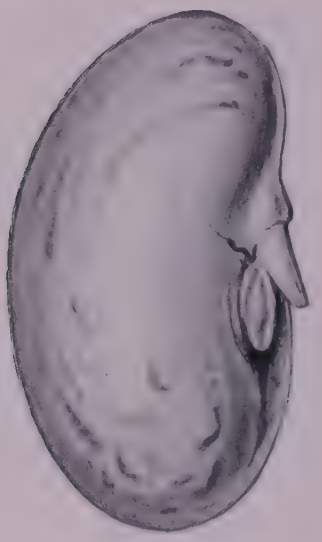


FIGURE 127.—A soaked Bean beginning to sprout.

FIGURE 128.—A soaked Bean with the skin and one lobe removed.

drawings. Sow a sprouting seed in a pot of wet sawdust and write your name on the side of the pot.

How does the bean differ from the seed of the plum ?

SUGGESTIONS FOR FURTHER WORK

Compare the seed of the bean with that of the pumpkin.

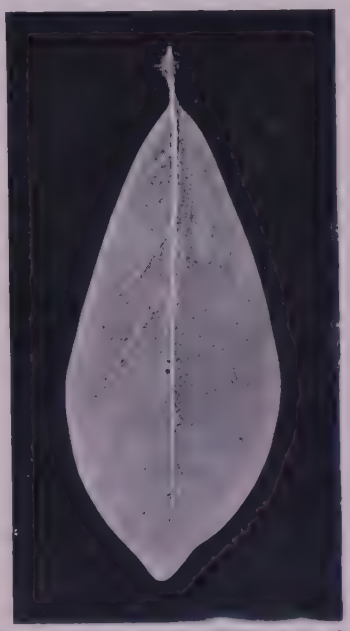
CHAPTER XV

PLANTS THAT GROW IN WINTER—SKELETON SHOOTS AND LEAVES

Plants that Grow in Winter

Just as more animals will have been found which are active in winter than might at first have been supposed, so among plants we may find numbers that are growing, and have sprung up from seed in the winter-time.

An interesting piece of nature-study will therefore be, to discover the plants that are actually increasing in size, in spite of the cold. At the same time it is worth while to notice the effects of frost upon vegetation, especially plants which are easily killed. For such work the garden will offer many opportunities.



From a photograph by Wilfred Mark Webb of a specimen kindly made by Mrs Brightwen, F.E.S.

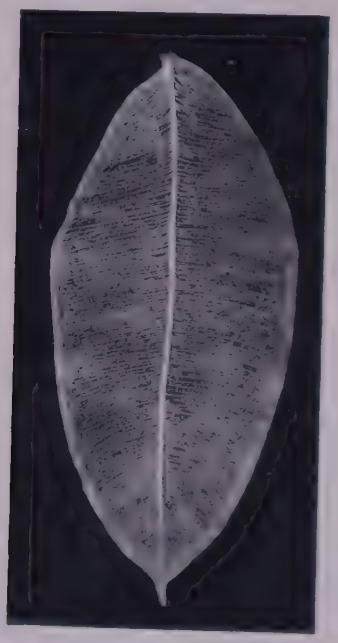
FIGURE 129.
Skeleton leaf of Magnolia.

Skeletons of Shoots and Leaves

Already we have suggested the tracing of the connection between the leaf veins and the strands in the leaf-stalk and stem. If one takes plants that have been subjected to cold for some weeks or months, it will be found that the soft parts have practically disappeared, and the skeleton

remains. As a rule, it is very brittle, and breaks easily; this matter may, however, be obviated to some extent by soaking the woody parts in glycerine and water.

Skeleton leaves, particularly upon the poplar, may also be found in a pretty fairly perfect condition, or these may be made (see figures 129 and 130) by soaking leaves in water and removing the soft parts, when they have become sufficiently rotten, by brushing them away.



From a photograph by Wilfred Mark Webb of a specimen kindly made by Mrs Brightwen, F.E.S.

FIGURE 130.—The skeleton of an Indiarubber-Plant leaf.

OBSERVATIONAL LESSON XVI

Part I—A Seedling

Preparations for work.

The pots containing sawdust in which beans were planted will be required.

Directions to the Pupil

Take out the seedling very carefully from the sawdust.

Record :—

The length of the root

Describe :—

Any structures growing from the root

Make :—

A sketch of the seedling as it now appears

Leave :—

A space for a water-colour drawing, to be made at your leisure

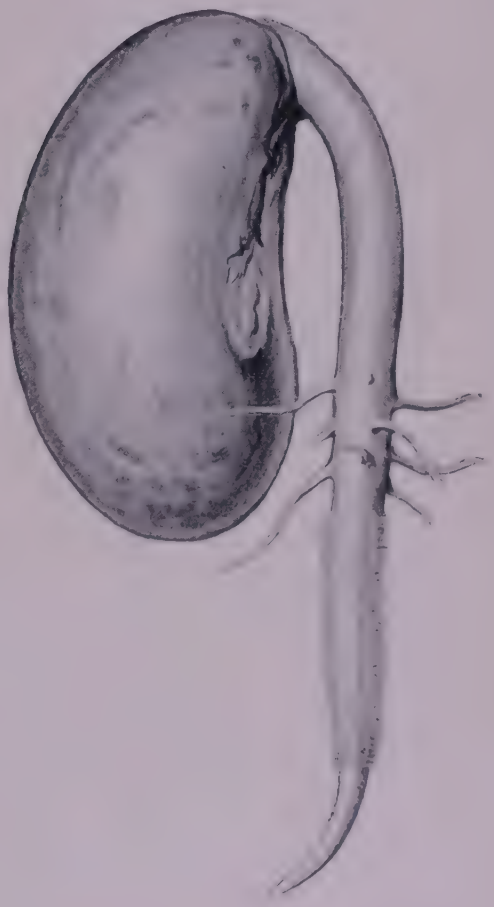


Figure 131.—A young Bean seedling.

Part II—A Leaf

Preparations for Work

Leaves of box will be required, some in a fresh state, and others that have been boiled for a considerable time.

Instructions to the Pupil

(1) Describe :—
- (*a*) The size
- (*b*) The shape
- (*c*) The colour
- (*d*) Three other characteristics

} of the box leaf

Make :—
- An outline drawing to scale

Leave :—
- A space

(2) Take a second specimen that has been boiled.

Note :—
- Any changes that have taken place
- Peel the skin from the under side

Sketch :—
- The veins as they appear when exposed

(3) Scrape the leaf with your nail until only the top skin is left. Describe this skin

Suggestions for Further Work in School

Take leaves of box that have been boiled in caustic soda or potash and carefully rinsed. With a paint brush, very carefully remove all the soft parts until only the skeleton remains.

CHAPTER XVI

THE CAPABILITIES OF SEEDLINGS

GIVEN some glass test tubes (such as are used in chemical laboratories), a supply of corks, pins and blotting-paper, it is possible to find out a great deal about the habits of seedlings and what have been called their instincts.

Beans that have been soaked for about twelve hours and kept under moist but airy conditions, and from which the roots have just begun to sprout, should be got ready. One of these should be fastened by means of a pin to the under side of a cork, on the side of which a groove has been cut, and the young root directed so that it will grow between the side of the tube (into which the cork fits), and a piece of damp blotting-paper placed against it. Keep a little water in the bottom of the tube and after the root has grown somewhat, turn the tube upside down so that it stands upon the cork. Note the behaviour of the root.

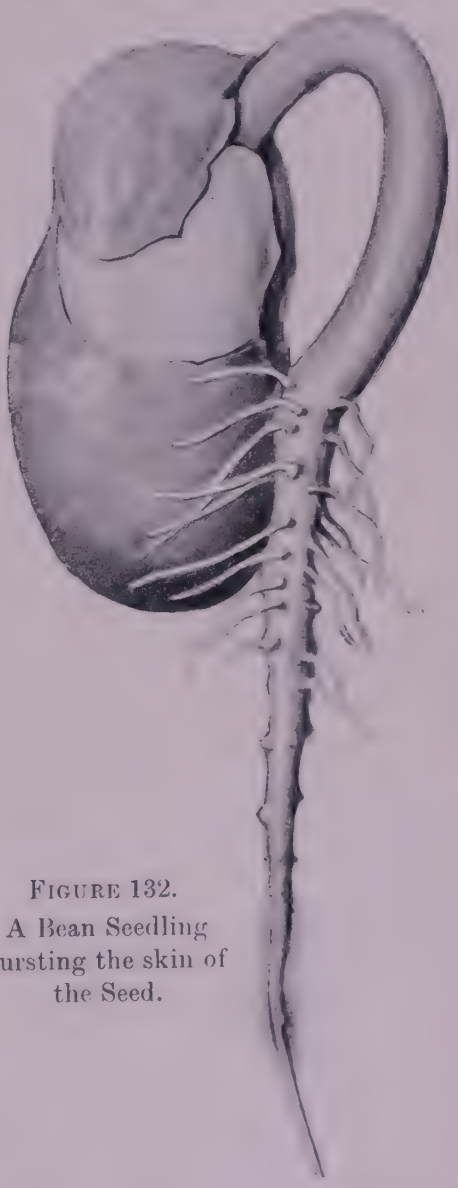


FIGURE 132.
A Bean Seedling bursting the skin of the Seed.

Keep a seedling in a tube into which a cork has been fitted which has no groove in its side.

Half fill a tube with blotting-paper, drop in a bean, put a grooved

cork loosely into top of the tube, place a known weight upon the top and see how much the seedling will lift.

Other seedlings may be grown so that the roots hang freely in the centre of a tube kept moist by a semi-cylinder of wet blotting-paper. Lines drawn upon the root at equal intervals (with Indian ink) will show very soon what parts of the root are lengthening.

From photograph by Wilfred Mark Webb.

FIGURE 133.—A Seedling showing growth when air is admitted to the tube containing it.

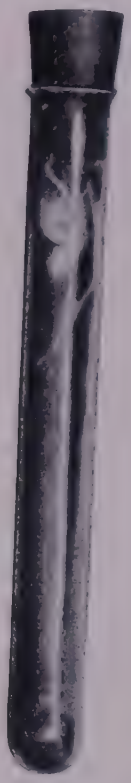


FIGURE 134.—A Seedling kept in a closely corked tube. No growth to speak of has taken place.

CHAPTER XVII

SUGGESTIONS FOR A SCIENCE COURSE *

If it be desired that the plants and animals which have been introduced into the course should be made the means of enabling the pupil to gain a rather more technical knowledge of the structure and function of living things, it is quite within the power of the teacher to make use of them. Such an extension of the lessons will involve some additional apparatus, if each pupil is to conduct his own experiments, which is no doubt the most satisfactory method. If circumstances should prevent this however, the teacher can perform some of them himself, as much as possible at the direction of the class. This direction, of course, only holds good in the case of physiological work. It is useless to attempt to investigate structure unless *each pupil* has the object in front of him to examine. *It should not, however, be forgotten that any such course must succeed the preceding lessons and should not in any way be substituted for them.* As practical teachers, the authors are convinced that a general course of nature-study should invariably precede anything like the acquisition of systematised knowledge, whether it deals with theoretical classification, or is limited to the investigation of one or two forms of life. They have found that such work is far less likely, in the case of young students, to produce that habit of mind,

* This chapter is intended rather for the use of the teacher than of the pupil.

necessary for all true scientific work. Unless a spirit of enquiry be first aroused, and powers of observation and deduction to some extent acquired, the study of what is known as elementary biology may produce little more than an exercise of the memory and an unthinking obedience to the directions of a practical manual. Knowledge thus derived, although perhaps useful in passing examinations, cannot be held as evidence of a satisfactory scientific education.

Again it is quite possible to pick out from among the lessons in this book and in Part II, all those which refer to the flowering plant and use them—with some elaborations which will suggest themselves—as *an introduction to the study of plant life.* For instance, after a preliminary exercise upon the parts of a plant the germination and structure of seeds may be considered.

When sufficiently advanced the seedlings can be made use of to prove that plants, to grow healthily, need light as well as air, and those sown in earth can be weighed from time to time.

The young plants as in the case of the bean, should be carefully drawn to scale.

So soon as the plants have stem, roots, and leaves, simple experiments should be devised to show the function of each of these.

Simultaneously with physiological experiments, the structure of the different parts can be examined, according to instructions prepared and distributed. The pupils should cut their own sections, and in every case make careful drawings with full explanations of their preparations. It is not desirable, except in special cases, to attempt any kind of microscopical technique, such as the making of permanent slides.

When the other work is done, the actual classification of flowers may be begun and the reasons for assigning the plant to its special order.

If the course in botany is to be extended, the lessons on a fern, a moss, and a mushroom mould should be introduced, and the yeast plant may be studied, though only in the case of the last-named are any physiological experiments advisable. In the case of yeast, however, the pupils should not omit to convince themselves of the fundamental differences between its method of nutrition and that of the bean.

ANIMALS

In the case of animals, nothing should be attempted except investigation of structure. This being the case, it is advisable to depart somewhat from the previously suggested plan, though as before, a highly organised form such as the frog should be taken first. The structure and development of this animal should be studied as thoroughly as possible, though not beyond the limits laid down in the late Prof. A. Milnes Marshall's admirable little book "The Frog." The great amount of detail insisted upon by Huxley, although doubtless theoretically an excellent training, has been found in practice to be quite impossible in the case of the ordinary student. After the frog has been fairly well mastered—an animal far from being typical of the class to which it belongs *—the pupil should be encouraged to examine as many amphibians as possible, beginning with the toad, though not in such great detail; and as a holiday exercise he should write an essay on amphibian structure as it appears to him. The other invertebrate animals dealt with in the lesson may next be considered, and in the same way a mussel, or far better a limpet, a crayfish, a hydra, and an amœba may be

* It is remarkable that the so-called "types" which run throughout our text-books are in nearly all cases quite non-typical, but highly specialised animals, *e.g.* the frog, hydra, mussel, crayfish, and earthworm.

examined. The teacher will of course find many suitable text-books, dealing with these animals, and the practical work will doubtless be interspersed with verbal explanations. At the same time we would like once more to point out that there is always a large class of students who have had no previous training in nature-study and in whom there may have been very little if any spirit of enquiry aroused. They will dissect out and draw a structure, only because they have been told to do so either in a lecture or by their text-books. Consequently, for these individuals, practical biology may be of little educational value. We have found it therefore useful in our own classes, to use a number of specially hectographed, or printed papers dealing with each "type," and so drawn up that the pupil has continually to be using his reasoning powers. Unless something of this kind is done, the work must in many cases be little more than a mechanical exercise. The proper direction of this work will call for previous zoological training on the part of the teacher, and unless he possesses it, it were better for him to omit anything like systematic zoology from his programme.

APPENDIX

A LIST OF MATERIAL, APPARATUS REQUIRED, WITH DETAILS AS TO WHERE IT MAY BE OBTAINED

In this Appendix, under the headings first of the Lessons and then of the Chapters, an endeavour has been made to lighten the task of making preparations for the special nature-study work suggested. In the case of the Lessons an approximate date has also been given.

Note.—*In the middle of September a mushroom bed and pans must be got ready for Lessons VI and VII.*

Lesson I. (4th week in September). *See* page 7.

Part I. Two *plums.*

Part II. *Dwarf Bean Plants* (in pots), *sown about the end of June.* The beans used in this book (*see* Figure 125) are "Sutton's Dwarf Sugar Beans," to be had direct from Sutton & Sons, Reading, price 2s. a pint, or 3s. 6d. per quart.

Lesson II. (1st week in October). *See* page 20.

Part I. *Dwarf Bean Plants.*

Part II. *Apparatus for observing the Sun,* made as described on pages 20 and 21.

Alternative Subject. *Seed Pods and Flowers of the Dwarf Bean.*

Lesson III. (2nd week in October). *See* page 32.

Part I. *Dwarf Bean Plants.*

Part II. *Apparatus for observing the Sun.*

Part III. *Living Sea Anemones,* which may be obtained from the Marine Biological Station at Plymouth (price 3d. each, postage 3d.

Actinia mesembryanthemum), and Port Erin Marine Biological Station (price 3d. each, or 2s. 9d. per doz., post free, packed in seaweed, such as *Actinia equina*).

LESSON IV. (3rd week in October). *See* page 41.

Part I. *Dwarf Bean Plants.*

Part II. *Apparatus for observing the Sun.*

Part III. *Living Crabs.* If some correspondent living at the seaside will not undertake to send specimens of shore crabs, these may be obtained from the Marine Station at Plymouth (price 4d. each, postage and packing 3d. or 6d., according to quantity).

NOTE.—*Soaked Bread must be put into the small covered glass jars described in Lesson VI.*

LESSON V. (4th week in October). *See* page 51.

Part I. *Sycamore Twigs bearing leaves* (and those of Elm Bird and Broom).

Tropaeolum (*Nasturtium*) *Shoots* that have been kept for some time in boiling water, or which have been exposed to the frost.

LESSON VI. (1st week in November). *See* page 68.

Part I. *Apparatus for observing the Sun.*

Part II. *Mouldy Bread in small covered glass pots.*

These $2\frac{1}{4}$ in. in diameter and $1\frac{5}{8}$ in. high described as "2 oz. extra squat covered glass pots," may be obtained from Messrs Vines & Froom, 75 Aldersgate Street, London, E.C. Price, 4d. each.

Fruit juice. Gelatine. This may be a piece of a "Chelsea Table Jelly" (to be obtained at the grocer's at 4d. a packet), dissolved in a little hot water or the prepared gelatine used in bacteriological laboratories could be used. The test tubes containing it should be placed in hot water previous to use. *Slips of glass.* Those with ground edges used for microscopic work (price at Messrs Watson & Sons, 313 High Holborn, 3s. 6d. per gross), are preferable to those which have been roughly cut. *Mouldy Lemons.*

Part III. *Mushrooms.* A bed must be prepared seven or eight weeks previously as described on pages 70 and 71.

NOTE.—*Hyacinths must be placed in glasses ready for Lesson X.*

LESSON VII. (2nd week in November). *See* page 76.

Part I. *Mould Dishes.* Prepared in Lesson VI.

Part II. *Button and older Mushrooms.* Pans previously prepared to show *Mycelium.* Spawn may be obtained from Mr R. E. Addey, North Grove House, South Ealing Road, Brentford. Price for 3 cakes 1s. 6d. post free, and 6d. per cake afterwards.

Part III. *Blindworms.* If these do not occur in the neighbourhood, specimens may be obtained from J. L. Wilson's, 37 New Oxford Street, London, W.C. Price (in winter) 1s. 6d. each.

LESSON VIII. (3rd week in November.) *See* page 84.

Part I. *Mould Dishes.* Prepared in Lesson VI.

Part II. *Hedgehogs.* To be obtained at J. L. Wilson's, 37 New Oxford Street, London, W.C. Price (in winter) 2s. 6d. each, or more cheaply through the "*Exchange and Mart.*"
Skulls of Hedgehogs.

LESSON IX. (4th week in November). *See* page 92.

Part I. *A Horse.* This should be borrowed—say from a tradesman.

Part II. *Skull and Limb-bones of a Horse,* and the *Skeleton of a Man.*

LESSON X. (1st week in December). *See* page 103.

Part I. *Hyacinth Bulbs.* The best way of obtaining these in quantities of two or three dozens is to send a commission to Mr J. C. Stevens, auctioneer, of 38 King Street, Covent Garden, at the beginning of the autumn, before the bulb sales begin.

Hyacinths growing in glasses, prepared a month or two previously.

LESSON XI. (2nd week in December). *See* page 110.

Part I. *Growing Hyacinths.*

Part II. *Short lengths of Oak Log* (about six inches or more in diameter) bearing the bark. These may be obtained from country timber merchants such as Messrs Robins, Lane & Pinniger, Marlborough, Wiltshire.

LESSON XII. (3rd week in December). *See* page 116.

Part I. *Growing Hyacinths.*

Part II. *River, Spring and Rain Water and apparatus for boiling and filtering it.*

LESSON XIII. (4th week in January). *See* page 123.

Part I. *Growing Hyacinths.*

Part II. Short lengths of thick *horse chestnut branch*, each bearing a *twig.*

LESSON XIV. (1st week in February). *See* page 129.

Cabbages with "solid hearts," or *Brussels Sprouts.*

LESSON XV. (2nd week in February). *See* page 133.

Dwarf Sugar Beans, dry and soaked; *Flower Pots containing Moist Sawdust.*

LESSON XVI. (3rd week in February). *See* page 137.

Part I. *Dwarf Bean Seedlings growing in Sawdust.*

Part II. *Box Leaves*, and some which have been well boiled.

INTRODUCTION.

The question of photography will be more aptly considered in Part II, as the autumn and winter do not lend themselves to work other than that which can be done with an ordinary camera. For the photographing of living and active creatures, it is advisable to have somewhat special apparatus, and in the Appendix to Part II a camera designed for such work will be described.

Page 4. The note-book alluded to on page 4 can be obtained from Messrs Spottiswoode & Co., of the Eton College Press. By the simple manipulation of a lace, any leaves in the book can be removed or rearranged. In this book, which is $11 \times 8\frac{1}{2}$ ins., the pages consist of ruled writing-paper on one side and drawing-paper on the other. The title is the "Eton Nature-Study Note-Book," and the price is 2s. Fresh leaves for insertion in the cover can also be obtained.

CHAPTER I.

Glass-top boxes can be obtained from Messrs Arundel & Marshall, of Penn Street Works, Hoxton. An estimate should be obtained for making boxes of the exact size required. Examples: $10\frac{1}{2}$ inches × 6 inches × 2 inches cost 5s. 10d. per dozen. *See* page 14.

To preserve them, succulent fruits and fungi should be kept in a mixture of equal parts of the following solutions—spirit 50°/₀, and formalin $2\frac{1}{2}$°/₀. *See* pp. 15 and 74.

CHAPTER III.

Southall Bros. and Barclay's Salt to be obtained from all chemists. *See* page 36.

CHAPTER XII.

Square jars and cylindrical jars can be obtained from Messrs Baird & Tatlock, Cross Street, Hatton Garden. *See* page 121.

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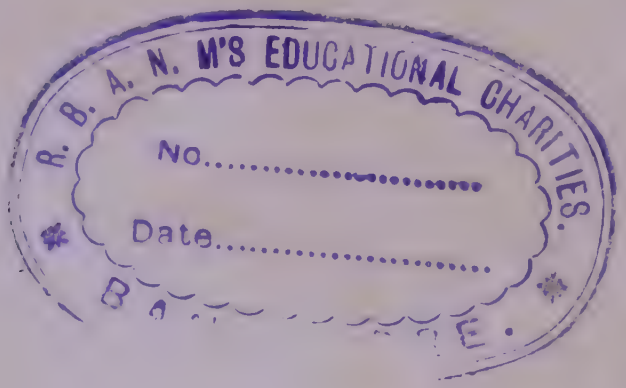

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